NATIONAL FOOD IRRADIATION RESEARCH PROGRAM

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT

OF THE

JOINT COMMITTEE ON ATOMIC ENERGY

CONGRESS OF THE UNITED STATES

EIGHTY-SIXTH CONGRESS

SECOND SESSION

ON

NATIONAL FOOD IRRADIATION RESEARCH PROGRAM

MARCH 31, 1960

PART 2

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NATIONAL FOOD IRRADIATION RESEARCH PROGRAM

THURSDAY, MARCH 31, 1960

CONGRESS OF THE UNITED STATES,
SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m., in room P–63, the Capitol, Senator Clinton P. Anderson presiding.

Present: Senators Anderson and Pastore; Representatives Price, Van Zandt, and Bates.

Also present: James T. Ramey, executive director; John T. Conway, assistant director; George F. Murphy, Jr., professional staff member, and Edward J. Bauser, technical adviser, Joint Committee on Atomic Energy.

Chairman ANDERSON. This is an open public hearing of the Subcommittee on Research and Development of the Joint Committee on Atomic Energy. Congressman Melvin Price, chairman of the subcommittee, has been delayed this morning by a legislative matter in the House. He requested me to open the hearing and expects to join us later.

The subcommittee hearing today is a continuation of hearings held before the full committee on January 14 and 15, as to the Army and civilian food irradiation programs, at which representatives of the Army and the AEC testified concerning the cancellation of the Army Food Irradiation Center. At that time the entire national food irradiation research program, both military and civilian, was in a state of confusion. Mr. Morse, Director of Research and Development in the Army, was unable to advise what the Army's future program would be except that it would concentrate on high dose sterilization. The AEC, which had been taken by surprise by the Army's decision, was attempting, in conjunction with the Interdepartmental Committee on Radiation Preservation of Foods, to formulate a national civilian program. An ad hoc panel of the Interdepartmental Committee was in the process of submitting its recommendations to the Committee. No one knew what the civilian and military food irradiation programs actually were or would be.

Since then a revised Army program has been announced. The Interdepartmental Committee has made its recommendations and the AEC has prepared its program. The hearing today is to discuss these plans and to ascertain what is our national program.

Accordingly, we have requested representatives from the Department of the Army, the Department of Defense, the AEC, and the Interdepartmental Committee on Radiation Preservation of Foods to be present this morning to explain the revised programs.

(Joint Committee letter requesting Department of the Army to testify follows:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., March 26, 1960.

Mr. RICHARD S. MORSE,
Director of Research and Development, Department of the Army,
Washington, D.C.

DEAR MR. MORSE: This will confirm previous oral notification to your office last week by the Joint Committee staff that the Subcommittee on Research and Development of the Joint Committee will hold a public hearing Thursday, March 31, 1960, at 10 a.m., and 2 p.m., in the Old Supreme Court Chamber (room P-63) of the Capitol Building, to consider the current status and future plans of the national food irradiation program.

I would appreciate it if you and other representatives of the Department of the Army who are familiar with the current status of the Army's portion of the program will be present to testify. In addition to other facts, the committee will be interested in an explanation of the March 1960 revised Army program compared with (1) the program prior to October 1959, and (2) the revised Army program recommended by the Quartermaster General in December 1959.

Sincerely yours,

MELVIN PRICE,
Chairman, Subcommittee on Research and Development.

Chairman ANDERSON. Our first witness will be Mr. Richard S. Morse, Director of Research and Development for the Department of the Army.

STATEMENTS OF RICHARD S. MORSE,* DIRECTOR OF RESEARCH AND DEVELOPMENT, DEPARTMENT OF THE ARMY; DR. JOHN L. SCHWAB, SPECIAL ASSISTANT TO DIRECTOR, R. & D.; MAJ. GEN. C. C. CALLOWAY, DEPUTY QUARTERMASTER GENERAL FOR OPERATIONS, OFFICE OF THE QUARTERMASTER GENERAL; BRIG. GEN. WILLIAM J. ELY, DIRECTOR OF ARMY RESEARCH, OFFICE, CHIEF OF RESEARCH AND DEVELOPMENT; DR. R. G. H. SIU, TECHNICAL DIRECTOR, R. & E. DIVISION, OFFICE OF THE QUARTERMASTER GENERAL; DR. J. B. YOUMANS, TECHNICAL DIRECTOR, U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND, OFFICE OF THE SURGEON GENERAL; COL. L. M. HURSH, CHIEF, MEDICAL RESEARCH BRANCH, U.S. ARMY RESEARCH AND DEVELOPMENT COMMAND, OFFICE OF THE SURGEON GENERAL

Mr. MORSE. I am very glad to be here, Senator.

Mr. Chairman and gentlemen of the committee, I am Richard S. Morse, Director of Army Research and Development and have been designated to represent the Army today. I have supporting witnesses whom I would like to introduce to you:

Dr. John L. Schwab, Special Assistant to the Director of Research and Development.

Maj. Gen. C. C. Calloway, Deputy Quartermaster General for Operations, Office of the Quartermaster General.

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*Background as furnished by the Department of the Army:
Mr. Richard S. Morse, following his resignation as president, National Research Corp., Cambridge, Mass., became Director of Research and Development for the Department of the Army on June 1, 1959. As Director of Research and Development, Mr. Morse is re-

Brig. Gen. W. J. Ely, Director of Army Research, Office, Chief of Research and Development.

Dr. R. G. H. Siu, Technical Director, R. & E. Division, Office of the Quartermaster General.

Dr. J. B. Youmans, Technical Director, U.S. Army Medical Research and Development Command, Office of the Surgeon General.

Col. L. M. Hursh, Chief, Medical Research Branch, U.S. Army Research and Development Command, Office of the Surgeon General.

Mr. Robert B. Foster, Jr. Chief, Property Division, Deputy Chief of Staff for Logistics.

(The full prepared statement of Mr. Morse will be found on p. 699.)

Mr. MORSE. In my previous appearance before the Joint Committee on Atomic Energy on January 14, 1960, I testified that, as a result of my investigation of the Army's food irradiation research program, I had suggested to the Army Chief of Staff that construction of a pilot plant at Sharpe General Depot, Stockton, Calif., be suspended indefinitely, and that the Chief of Research and Development, Department of the Army, prepare and submit a revised research program on radiation preservation of food, stressing fundamental studies. This pilot plant was designed with food processing lines and radiation sources to sterilize approximately 1,500 pounds of meat per hour—operated on a 24-hour schedule, it would have been capable of supplying meat to approximately 30,000 troops.

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sponsible for supervision of the Army research and development program with the authority and responsibility equivalent to that of an Assistant Secretary.

Mr. Morse was born on August 19, 1911, in Abington, Mass., and received a bachelor of science degree from Massachusetts Institute of Technology in 1933. Following graduate work in physics at the Technische Hochschule, Munich, Germany, he spent 5 years in research work at Eastman Kodak Co. and Distillation Products, Inc., in Rochester, N.Y. In 1940, Mr. Morse organized National Research Corp. and served as its president until his resignation in 1959. National Research Corp. is one of the country's principal suppliers of industrial vacuum equipment and has played a prominent part in the development of new processes for vacuum dehydration, vacuum metallurgy, vacuum metalizing, production of rare metals, and petrochemical production.

Mr. Morse is generally recognized as one of the early pioneers in the field of high vacuum technology and has been particularly successful in the launching of new business ventures in partnership with other industrial organizations. He has been associated with many new technical enterprises growing out of research activities of National Research Corp. He has, at one time, served as president and director, Columbia-National Corp.; president, NRC Equipment Corp.; president, Minute Maid Corp.; president, NRC Metals Corp.; director, Escambia Chemical Corp.; president, Vaculite Corp.; and president, Vacuum Metals Corp.

Mr. Morse also has been associated with various engineering and development programs relating to the national defense effort. In addition to having acted as civilian adviser to the Atomic Energy Commission and the Office, Secretary of Defense, he has served on the following committees: the Army Ordnance Research and Development Advisory Committee; the Technical Advisory Panel of the Department of Defense on Chemical, Radiological, and Biological Warfare; the Army Scientific Advisory Panel; and the Defense Science Board. Mr. Morse was Chairman of the Army Scientific Advisory Panel from October 1958 until May 1959. In 1959 he received the honorary degree of doctor of engineering from Brooklyn Polytechnic Institute.

Organization memberships include the American Chemical Society and the Institute of Aeronautical Sciences. Club memberships are St. Botolph (Boston), Army-Navy Club, and Quissett Yacht Club.

The reasons which I gave for my decision to suspend construction of the pilot plant and to reorient the research program were:

(*a*) Lack of studies confirming any substantial economic advantage to the Armed Forces accruing from the use of irradiated foods.

(*b*) Lack of an urgent operational requirement.

(*c*) Evidence of animal anomalies resulting from the wholesomeness studies.

(*d*) Unsolved complex fundamental research problems requiring resolution prior to the initiation of large-scale operations. Typical of such are:

1. Development of procedures for improving the taste, appearance, odor, and troop acceptability of irradiated foods, particularly beef—a high tonnage item.

2. The identification of chemical changes in foods resulting from the irradiation process.

3. Studies on the mechanism and procedures for controlling proteolytic enzymes.

4. Studies on the mechanism of killing radioresistant micro-organisms.

5. Development of suitable packaging materials and procedures.

At the time of my previous testimony I had not received the revised research program which I had requested from the Chief of Staff. By memorandum dated March 7, 1960, the Vice Chief of Staff of the Army forwarded to my office a copy of the revised research program. On March 10, 1960, I forwarded the Army program to the Director of Defense Research and Engineering for his approval. On the same date I forwarded the approved plan to the Assistant to the Secretary of Defense (Atomic Energy). It is my understanding that copies of this correspondence and the approved program have been made available to your committee. I have copies of this correspondence and the approved plan which I should like to submit at this time for the record.

Chairman ANDERSON. Without objection, we will place them in the record.

(The correspondence referred to follows. See pt. 1, p. 243, for the March 1960 revised program.)

MARCH 7, 1960.

Memorandum for: Director of Research and Development.
Subject: Revised Army food irradiation program.

1. In your memorandum of September 10, 1959, concerning the Army irradiated food program you requested that the Chief, Research and Development, submit a revised research program directed toward fundamental studies in the field of food irradiation. This program would be exclusive of all work relating to acceptability studies and the feeding of humans except on a very limited scale consistent with future interpretation of animal work.

2. My memo to you of October 15, 1959, advised that the Quartermaster General had been instructed to prepare and submit a revised detailed research program oriented toward the early determination of the wholesomeness of certain key dietary items of irradiated food. The revised Quartermaster research plan has been received and is attached.

3. The revised program describes research tasks for the solution of unsolved fundamental research problems in the general areas of military applications and economic analysis, assurance of wholesomeness, pre- and post-irradiation studies, destruction of micro-organisms, nuclear effects on food, acceptance testing, and development of packaging. As a part of the revised program, the Quartermaster General states a requirement for new radiation source instruments and asso-

ciated minimal food preparation facilities to support the fundamental research proposed in this program.

4. The revised plan has been subjected to critical Army staff review and analysis, the details of which are at inclosure 2.

5. Pertinent to any decision on the revised Army irradiated food program are the continuing interest of Congress and the national civilian program now under consideration by the Interdepartmental Committee on Radiation Preservation of Food. The proposed revised program and research facility will complement the national civilian program.

6. Approval of this program will require $500,000 R.D.T. & E. money in addition to the $500,000 currently programed for this project in the President's budget for fiscal year 1961. Following notification of your position in this matter, the necessary action can be taken to support the funding requirements of the program for fiscal year 1961.

7. I recommend that you take the following actions with respect to this program:

(*a*) Approve the Quartermaster revised research program at enclosure 1, with the exceptions enumerated in the draft implementing instructions to the Quartermaster at enclosure 5.

(*b*) Approve and transmit the proposed memorandum at enclosure 3 to the Director, Defense Research and Engineering, outlining the Army's revised program and seeking DOD approval thereof, including the changed utilization of the funds now in AEC.

(*c*) Approve and transmit the proposed memorandum at enclosure 4 to the Assistant to the Secretary of Defense (Atomic Energy) for use by that office in informing the Joint Congressional Committee on Atomic Energy of the Army's action with respect to this program.

G. H. BECKER,
General, U.S. Army, Vice Chief of Staff.

DEPARTMENT OF THE ARMY,
OFFICE OF THE DIRECTOR OF RESEARCH AND DEVELOPMENT,
Washington, D.C., March 10, 1960.

Memorandum for: The Director of Defense Research and Engineering.
Subject: Revised Army irradiated food program.

1. Shortly after assuming my present office on June 1, 1959, I initiated an investigation of the Army's irradiated-food program with special attention to the plans for construction of a $7.5-million pilot plant at the Sharpe General Depot, Stockton, Calif.

2. My findings led me to suggest to the Army Chief of Staff, by memorandum of September 10, 1959, that the planned construction of the pilot plant be suspended indefinitely and that the Chief of Research and Development, Department of the Army, prepare and submit a revised research program emphasizing fundamental research.

3. The revised Army irradiated-food program, which I had requested, has been submitted to my office for approval. A copy is attached as enclosure I.

4. The revised program describes seven major research tasks to be accomplished over a 6-year period (fiscal years 1961–66, inclusive). These research tasks are oriented toward resolving the unsolved fundamental research problems associated with the subject program in the areas of military applications and economic analyses, assurance of wholesomeness, pre- and post-irradiation studies, microbiology, nuclear effects on foods, acceptance testing, and development of packaging. The cost of the research proposed is $5.130 million over the 6-year period. The fiscal year 1961 research funding level proposed by the Quartermaster was $1.265 million. The Army staff review of the revised program scaled this amount to $1 million. The President's fiscal year 1961 budget provided only $500,000 for radiation preservation of food research. Therefore, a deficiency of $500,000 research funds in fiscal year 1961 exists. Approximately $300,000 of this deficiency could, with your approval, be funded out of the unexpended balance of DOD emergency R. & D. funds passed to AEC in fiscal year 1958 by the Army for construction of the original hi-fi component of the suspended pilot plant.

5. Adequate support of the revised program necessitates the construction of a radiation research facility consisting of a variable voltage 1–12 MEV (million

electron volt) linear electron accelerator; a 1-million curie Cobalt-60 gamma radiation instrument; and minimal associated food preparation and laboratory facilities. The required research capabilities had been incorporated in the proposed pilot plant, construction of which has been suspended.

6. The cost of the required research facilities is estimated as follows:

Food preparation facilities	$300,000
Electron accelerator (Linac)	400,000
Cobalt 60 irradiator (Hifi)	1,100,000
Estimated total	1,800,000

The Quartermaster General proposes that the construction of the radiation research facility be funded out of the approximately $2,100,000 unexpended Department of Defense emergency research and development funds of the original $2,500,000 which was passed to the Atomic Energy Commission by the Army in fiscal year 1958 for construction of the Hifi component of the suspended pilot plant; $400,000 of these funds has been spent on design of the original Hifi; $650,000 of other funds has been spent on the original Linac on which construction is about 60 percent complete. The work accomplished for these sums will, in part, contribute to the planned construction of the revised research facility. It is proposed to modify, for the estimated $1,800,000 above, the original Linac and Hifi specifications to evolve research rather than pilot plant instruments.

7. It is my intention to approve the QM revised irradiated food program with respect to the proposed research. I am convinced that the proposed supporting research facilities are necessary for proper conduct of this program. I should, therefore, like to concurrently grant approval for construction of these requested facilities. Prior to taking this course of action, I should like to obtain Department of Defense approval of the proposed funding for the revised program research facility and fiscal year 1961 research portion of the program. While the $2,500,000 was originally furnished by DOD to the Army for the express purpose of constructing a cobalt 60 source for the pilot plant, I feel that the use of the residue of this sum for modification and completion of the Varian Associates Linac, construction of a modified Hifi together with minimal associated food preparation facilities, and partial funding of the fiscal year 1961 research funds deficiency is a sound investment of research and development funds.

8. I recommend your approval of the plan for funding the proposed research facility and part of the fiscal year 1961 research proposed in this program out of the $2,100,000 unexpended balance of the $2,500,000 Department of Defense emergency research and development funds now in the AEC possession. An early reply will be greatly appreciated.

RICHARD S. MORSE,
Director of Research and Development, Department of the Army.

MARCH 10, 1960.

HON. ROBERT B. LOPER,
Assistant to the Secretary of Defense (Atomic Energy),
Washington, D.C.

DEAR GENERAL LOPER: On January 14, 1960, before an open session of the Joint Committee on Atomic Energy, Congress of the United States, I presented a detailed history of the Army's research efforts in the radiation sterilization of foods field together with an explanation of my actions taken with respect to the program.

I testified that, as a result of my investigation of this program, I had suggested to the Army Chief of Staff that the planned construction of a pilot plant at Sharpe General Depot, Stockton, Calif., be suspended indefinitely, and that the Chief, Research and Development, Department of the Army, prepare and submit a revised research program on radiation preservation of food stressing fundamental studies.

At the time of my testimony I had not received the requested revised research program and so stated to the committee. The committee requested that its memebrship be informed when I had received the revised program and rendered a decision relative to the future scope and direction of the irradiated food research effort.

I have now received the Quartermaster Corps proposed revised program, food preservation by ionizing energy, with a recommendation from the Army Chief of Staff that the program, with minor modification, be approved.

The revised program represents a 6-year, $5.130 million effort with a recommended level of funding for fiscal year 1961 of $1 million. Seven research tasks in the areas of military applications and logistic analyses, assurance of wholesomeness, pre- and post-irradiation studies, destruction of microorganisms, nuclear effects on foods, acceptance testing and development of packaging comprise the research program. Integral to the proposed revised program is the requirement for a supporting radiation research facility which will include a 1–12 Mev (million electron volt) variable voltage linear electron accelerator (Linac); a million curie cobalt 60 gamma irradiator (Hifi); and minimal associated food preparation and laboratory facilities.

Funds for the support of the fiscal year 1961 research portion of the program are available within resources of the Chief, Research and Development, Department of the Army.

The revised program proposes that the funds for construction of the research facility and approximately $300,000 of the $1 million planned research for fiscal year 1961 be obtained from the approximately $2.1 million unexpended balance of the original $2.5 million DOD research and development emergency funds provided the Army in fiscal year 1958 and passed to the AEC for construction of a cobalt 60 high intensity food irradiator (Hifi) component of the now suspended pilot plant. Estimated additional cost of the proposed research facility is $1.8 million which includes $300,000 for the food preparation and laboratory adjunct; $400,000 for the revised Linac; and $1,100,000 for the revised Hifi. The $1.8 million cost of the proposed research facility is in addition to the $400,000 already spent on design of the original Hifi and the $650,000 spent for design and construction of the original Linac (now 60 percent complete). Some portion of the work accomplished with the moneys previously expended will contribute to the design and construction of the revised Hifi and Linac instruments.

I have approved the revised program with minor modifications related to time phasing of certain work and the associated funding. In this connection, I have requested that the DOD grant to the Army the requisite authority for application of the unexpended balance of the previously mentioned fiscal year 1958 DOD research and development funds, now in AEC possession, to the funding of the construction of the revised research facility, and partial funding of the fiscal year 1961 research. I am confident that my request will receive favorable consideration.

The revised research program which the Army contemplates is complementary to the national civilian radiation processed foods program currently sponsored by the Interdepartment Committee on Radiation Preservation of Food. The Army proposes to support to the maximum the civilian program.

In summary, it can be said that the Army is continuing to foster actively fundamental research in the radiation preservation of food field.

I will keep your office informed of future developments in this area in order that you may, in turn, keep the membership of the Joint Committee on Atomic Energy fully and currently aware of the Army's activities in the radiation preservation of food field.

Sincerely,

RICHARD S. MORSE,
Director of Research and Development.

MARCH 11, 1960.

Memorandum for: The Chief of Staff.
Subject: Revised Army food irradiation program.

1. Reference your memorandum, subject as above, dated March 7, 1960, with five enclosures.

2. The Quartermaster plan, modified in collaboration with representatives of the Chief of Research and Development and the Quartermaster General, as shown in enclosure 2, is approved for implementation. The memoranda to the Assistant to the Secretary of Defense (Atomic Energy) and Director Defense Research and Engineering have been signed and forwarded.

RICHARD S. MORSE,
Director of Research and Development.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C., March 24, 1960.

Memorandum for: The Director of Research and Development, Department of the Army.
Subject: Revised Army irradiated food program.
Reference: Department of the Army memo to DDRE dated March 10, 1960, same subject.

This office is in general agreement with the revised food irradiation program as outlined in the reference, subject to the understanding that you will investigate further the desirability of using a less expensive and more appropriate linear accelerator rather than the high capacity 24 Mev. machine proposed; and that the proposed program for the succeeding fiscal year can be supported from the Regular Army R.D.T. & E. appropriations.

In granting this program approval it is assumed that the necessary funding arrangements and any matters pertaining to the facilities involved will be accomplished through established channels.

HERBERT F. YORK.

MARCH 28, 1960.

Memorandum for: The Chief of Research and Development.
Subject: Revised Army irradiated food program.

1. Reference: Director of Defense R. & E. memorandum for the Director of Research and Development, Department of the Army, above subject, dated March 24, 1960, copy attached.

2. The Director of Defense Research and Engineering by referenced memorandum has granted program approval of the revised irradiated food program subject to the understanding that the desirability of using a less expensive and more appropriate electron radiation source, rather than the high capacity unit proposed, will be investigated and that the proposed program for the succeeding fiscal years can be supported by the regular R.D.T. & E. appropriations.

3. It is requested that you review the desirability of using a less expensive low capacity research electron radiation source rather than modifying the high capacity unit now being designed and fabricated by Varian Associates, Inc. Such review should carefully consider the total relative net cost of each unit including associated facilities, building, utilities, and operating costs as well as salvage value of the present incomplete unit. It is requested that you inform me of your decision on this matter by April 20, 1960.

4. It is further requested that you take appropriate action to implement this revised program.

RICHARD S. MORSE,
Director of Research and Development.

Mr. MORSE. On March 24, 1960, I received general program approval from the Director of Defense Research and Engineering.

Before discussing the revised program I believe it necessary to clarify two important points concerning the Army's program.

Chairman ANDERSON. When you say that you have copies of correspondence and the approved plan which you would like to submit for the record, we have in our record this revised program which was put in, in the previous hearings. Is that the revised program you are referring to?

Dr. SCHWAB. That is right.

Mr. MORSE. First, it has been suggested in some quarters that the Army has "dropped the ball" with respect to its effort in the radiation preservation of food research field. The suspension of the construction of the pilot plant at Stockton, Calif., has been misinterpreted as indicating that the Army's program has been canceled. The facts are that the Department of the Army has maintained, without interruption, an active research program from 1954 to the present, and is continuing an active research program.

Secondly, there appears to be a misunderstanding relative to the extent of the Army's interest in, and work on, the low-dose—pasteurization—radiation treatment of foods. The current Army program, while emphasizing research in high-dose treatment—sterilization—of foods, has not neglected low-dose treatment—pasteurization. We have made significant contributions in the low-dose area. The Quartermaster General is preparing a detailed technical monograph on the work which the Army has accomplished in the low-dose treatment of foods.

The revised Army research program provides for an expenditure of $5.130 million for fundamental research over a 6-year period (fiscal years 1961–66, inclusive). The research will be conducted under seven major tasks.

1. Military applications and economic analyses;
2. Assurance of wholesomeness;
3. Preirradiation and postirradiation studies;
4. Destruction of micro-organisms;
5. Nuclear effects on foods;
6. Acceptance testing; and
7. Packaging studies.

To support this program it is necessary to construct a radiation research facility which will include:

1. A variable voltage electron accelerator.

The linear accelerator was originally designed as a high volume processing unit for installation at the Stockton facility. To date approximately $600,000 has been expended for design and partial fabrication. Although this unit is not ideally suited as a research unit, it is capable of being modified and completed to meet the needs of the research program. However, before final decision, a detailed review will be made to determine the desirability of using a less expensive electron accelerator more suitable as a research tool.

Chairman ANDERSON. Mr. Morse, that top item of $80,000, on the chart you have on the stand, that has been added in the last day or two? (See chart 2, p. 694.)

Mr. MORSE. General Ely, would you care to comment?

Chairman ANDERSON. It is not what you sent us yesterday.

General ELY. It is not in the program as we approved it for the Quartermaster General to conduct with the funds to be made available to him.

Chairman ANDERSON. Wouldn't it be proper to say that it had been added recently?

General ELY. That is correct, sir. That item will be funded from Army Research Office funds, not made available to the Quartermaster General for the conduct of his program.

Chairman ANDERSON. How about next year? The Quartermaster wanted $80,000 for next year also?

General ELY. We feel that $80,000 will do the work on an evaluation of the logistics and economics that we need at this time.

Mr. MORSE. We have put that in red to indicate that it is not wholly within the Army Quartermaster program. These are funds within the Army. It is not work to be done by the Quartermaster Corps. It is a logistical study to be done by the Office of Research and Development.

Chairman ANDERSON. You had a chart in December that showed a need for $80,000 for 1961 and $80,000 for 1962. That was in December. Has that been changed and only one $80,000 is going to be used?

General ELY. The December chart that you have made reference to is the program submitted by the Quartermaster General as they felt the money should be spent for the conduct of future research. The program that we have drawn, revising slightly other features of the Quartermaster General's program, includes this change and a few others.

Mr. MORSE. I think, Senator, you are looking at the original program and not the revised one.

Chairman ANDERSON. Yes, but the original program with the two $80,000 figures in was not approved by just one group, but by the National Research Council-National Academy of Sciences, and by the Chairman of the Committee on Irradiation Preservation of Food. I am trying to find out what expert decided to take it out and in the last 48 hours put part of it in for this year.

Mr. MORSE. That is not quite the way it happened.

Chairman ANDERSON. This has a December dateline instead of the current one which does not have the December dateline.

Mr. MORSE. The program which you have in your right hand is the draft program (December 1959) which was not approved by the Chief of Staff of the Army. (See pt. 1, pp. 147, 164.)

Chairman ANDERSON. But the item of $80,000 was approved, was it not, by this group? The National Academy of Sciences said in their opinion the proposed December funding should be recognized as minimum. That was the program presented by the Quartermaster Corps to the National Research Council and National Academy of Sciences who said:

> The program as presented by the Quartermaster Corps is an excellent one, execution of which will require adequate funding. In our opinion the proposed funding as requested should be recognized as minimum. (See pt. 1, p. 240.)

That included two $80,000 items. Then when you sent us this a day or two ago it had no $80,000 item at all. This morning there is one $80,000 item in. I am trying to find out how they come in and how they come out.

General ELY. I believe I can explain it, sir. All of this relates to the problem of funding. The program that the Quartermaster General submitted is the program he would like to see carried forward assuming that the funds could be made available. The program that was approved by the National Research Council is also the one that they would like to see carried out, assuming the funds could be made available. When we get to the funding for fiscal year 1961 we find that we do not have in the Army program sufficient funds to do what was proposed in the Quartermaster General's program of December.

Chairman ANDERSON. By $265,000.

General ELY. That is correct.

Chairman ANDERSON. They wanted $1,265,000 and you have a million.

General ELY. That is correct, sir. So we are making available to the Quartermaster under our present approved program a million dollars for their part of the continuation of the food research program. We will carry out with funds in the Army Research Office the

logistic and economic studies in the first year which we believe will answer the questions that we think need to be answered.

Chairman ANDERSON. In your footnote, Mr. Morse, you mention this linear accelerator.

Mr. MORSE. Yes, sir.

Chairman ANDERSON. I received my copy of the April issue of Nucleonics yesterday, and I was reading that last night, and on page 31 I came across this paragraph:

> The Army's new research center successor to Stockton, Calif., will include an electron accelerator built by Varian Associates with a $400,000 support lab. The site will be selected after a thorough review of the needs of both the Army and civilian programs. The latter is expected to make use of the Army facilities as well as X-ray machines. Varian has done 80 percent of the work on a 24-Mev. Linac for the Army and will scale it down to 12 Mev. at a cost of $400,000. One million is available for the cobalt 60 source.

Do you regard that as a reasonably accurate report of what has taken place?

Mr. MORSE. Not completely.

Chairman ANDERSON. What is inaccurate about it?

Mr. MORSE. I don't know whether we are or are not going to use the current Linac. I suspect we will. We intend to find the cheapest means of getting a source of electrons. We agree and the AEC concurs with us that we do need an electron source. I have not seen that article and I have no idea where the editor got the information. So I really can't comment on it very intelligently.

Chairman ANDERSON. Did the AEC recommend the linear accelerator?

Mr. MORSE. Recommend it?

Chairman ANDERSON. Recommend it, yes.

Mr. MORSE. I can't say they recommended it. I don't know that it is exactly their province to recommend what we do. I had luncheon the day before yesterday with the AEC people and it was my impression that we were generally in agreement that as a research tool it was desirable and essential that we proceed with an electron source. Whether this is the one we use or not is subject to a good hard look-see in terms of dollars.

Chairman ANDERSON. You did send them the report to review and they did review it on December 11 and General Luedecke sent back a letter to General McNamara, Quartermaster General, and said that—

> "The necessity for a linear accelerator is less apparent, however. It appears that requirements relating to study of induced radioactivity can probably be fulfilled with existing facilities. With information presently available to us, we could not concur in the need for a linear accelerator at this time."

The complete letter from which I am reading is set out on pages 238 and 239 of the printed hearings. (See pt. 1, pp. 238–239.)

Mr. MORSE. I have been informally advised, and I assume you are going to discuss this with the AEC representatives—you can ask them now if you care to—if they would concur that as a research tool we should study and employ a linear accelerator or at least a source of electrons.

Chairman ANDERSON. Is there anyone from AEC to comment on this?

Mr. FLOBERG. I am here, Senator.

Chairman ANDERSON. Does this statement by General Luedecke represent the position of the AEC or not?

Mr. FLOBERG. I think I can state the position this way. I was aware of General Luedecke's letter although not until recently. I think it can fairly well be said that the use of an electron source is a useful addition to the program, and that it should not be dismissed out of hand by any manner of means, because it does have certain advantages over the cobalt source, or at least certain different applications from the cobalt source. Therefore, it can't be considered an extravagant tool in that sense.

Chairman ANDERSON. What did the Surgeon General say about it, Mr. Floberg?

Mr. FLOBERG. The Surgeon General?

Chairman ANDERSON. Did he recommend against the use of it?

Mr. FLOBERG. I don't know, sir.

Chairman ANDERSON. Mr. Morse, do you know whether he did?

Mr. MORSE. We have Dr. Youmans here who is representing the Surgeon General. I suggest he answer himself.

Chairman ANDERSON. Did the Surgeon General recommend against this as inducing radioactivity?

Dr. YOUMANS. He did not recommend it.

Chairman ANDERSON. He did not recommend against it?

Dr. YOUMANS. No, sir. He did not recommend it. He did concur in its use as a research tool.

Chairman ANDERSON. Did he recommend against using it as a part of these facilities?

Dr. YOUMAN. He recommended against using it in the production of food in which induced radiation might occur, but not as a research tool.

Chairman ANDERSON. Was any attention paid to the recommendation of the Surgeon General?

This is not purely in a research sense. This is a facility for the irradiation of food.

Mr. MORSE. No, sir, this is not. This is a research facility and we are not going to produce food. I want to make that perfectly clear. It has been my position from the beginning, not to go ahead with Stockton on the basis it was premature in the light of the state of the art, the projected cost, and any urgent military requirement. We are now discussing additional research to find whether we can or cannot effectively irradiate food and end up with a useful product, either for peaceful use or for the military. I think as far as the electron source is concerned, we are all concerned with any prospect of induced radioactivity, as I gather you are by your line of questioning.

Chairman ANDERSON. Exactly.

Mr. MORSE. I have investigated this as thoroughly as I can with the Office of the Surgeon General, Dr. Youmans, and the Atomic Energy Commission. You will note that while the original requirement for LINAC was 24 million volts, this is not our intention. We are going to redesign the unit. I doubt very much personally whether we will ever use it above 5 million volts. As a research tool we need a variable voltage electron source—and that is precisely the terms I have used in my statement—a variable voltage electron accelerator. I do not say LINAC or one made by Varian.

Mr. FLOBERG. This letter of General Luedecke was written at the time that a 24 million electron volt accelerator was under discussion and referred to that level of energy accelerator.

Mr. MORSE. That is the type of thing which the Surgeon General was directing his interest to and very properly. I think it was a mistake and we admit it.

Representative BATES. Do you expect to locate this at Natick?

Mr. MORSE. There is no decision to locate it now.

Representative BATES. Does the Army expect to centralize its food research at Natick?

General CALLOWAY. As I understand the question, is it the intention of the Quartermaster Corps to centralize its food research at Natick. That has been so recommended by the Quartermaster.

Chairman ANDERSON. Would that include this?

General CALLOWAY. At that time it did not include this because we had no approved program. It might be advantageous to include it at Natick. Our directive from the Chief of Research and Development requires that a study be made to determine the location of this facility.

Representative BATES. Would it make sense to put all your research specialists together?

General CALLOWAY. It appears that it would.

Representative BATES. And isn't the space available up there?

General CALLOWAY. I think it is.

Representative VAN ZANDT. I am a member of a two man committee of the House Armed Services Committee charged with the responsibility of looking into this research effort at Massachusetts. Would you restate the policy again of the Quartermaster General?

General CALLOWAY. It is to concentrate his research facilities at Natick. The question is food research facilities.

Representative VAN ZANDT. That means the removal of your research as far as food is concerned from the Chicago area.

General CALLOWAY. As far as the food laboratories are concerned; yes, sir.

Mr. MORSE. I think you should realize that the principal research facilities of the Quartermaster Corps are at Natick in terms of people and assets. The Food Containers Institute is the only portion left in Chicago.

General CALLOWAY. We have five research divisions in the organization at Natick and two at Chicago.

Representative BATES. You intend to close the ones at Chicago?

General CALLOWAY. That is the Quartermaster's desire.

Representative VAN ZANDT. What have you at Natick at the moment?

General CALLOWAY. We have five research divisions consisting of pioneering or basic research. We have human environmental research. We have chemical and plastic research. Clothing, textile, and footwear research and mechanical items research for which the Quartermaster General is responsible, and the command headquarters.

Representative VAN ZANDT. What did you take from Philadelphia?

General CALLOWAY. We took primarily the clothing and textiles.

Representative VAN ZANDT. You have not yet made a decision as to whether or not you would locate this accelerator there?

General CALLOWAY. No, sir. We have been directed by the Chief of Research and Development to make a study and submit it to him with our recommendations, which will get underway soon.

Representative BATES. Would it make sense to put it all together?

General CALLOWAY. To me, yes, sir.

Representative BATES. What argument would you have to the contrary?

General CALLOWAY. I don't know, unless there would be some safety requirements which could not be met at that location. I know of none at this time.

Mr. MORSE. I would say that congressional arguments would be the principal ones involved of not putting it in Natick.

Representative BATES. We would like to remove ourselves from that and just operate on the basis of facts.

General CALLOWAY. I have spent the last 5½ years commanding the Research and Development Command with headquarters at Natick, and I agree with the statement as made.

Chairman ANDERSON. Now the question has been raised of operating on fact. I want to ask Mr. Floberg if he is real sure that Mr. Luedecke's letter was written about the early program or revised program, because it was dated December 11 and he said the Atomic Energy Commission appreciated the opportunity to review the draft revised Army program, and it had been cut from 24 to 12 million electron volts. What is the basis for your statement that it was not?

Mr. FLOBERG. I thought it was. I thought they were still talking about 24.

Chairman ANDERSON. When they say they are not?

Mr. FLOBERG. That was our understanding at the time. If I am wrong, I am wrong.

Chairman ANDERSON. I don't know. I am just following Mr. Bates' injunction of trying to get down to the facts. I call your attention to the fact that this was December 1959. It is not the original program but the revised Army program.

Mr. MORSE. That is a draft program, Mr. Senator, which your staff insisted on having before it was adequately staffed in the Army. I agreed to send it over against my better judgment.

Chairman ANDERSON. I call attention to page 11, Mr. Floberg:

Considering the valuable and needed data which can be obtained, if the Army is to complete the present linear accelerator, in order to realize this at reasonable cost the design criterion should be reduced from 24 MEV to 12 MEV. (See pt. 1, p. 161.)

This is the revised program. On that General Luedecke commented.

Mr. FLOBERG. Maybe I was just plain wrong on that. Let me check up on it and let you know. (See Commissioner Floberg's letter, p. 745.)

Chairman ANDERSON. There is a possibility of confusion on the documents in here.

Mr. MORSE. Senator Anderson, may I try to clarify this at this point?

Chairman ANDERSON. Surely.

Mr. MORSE. That copy you have is a revised copy but it has not been staffed, it has not been approved by the Army and I wish you had never seen it. Your staff insisted on getting it before we had a revised program approved by General Trudeau. I want to emphasize that the AEC has consistently been opposed to the LINAC high-voltage unit. I know the Surgeon General and medical people have been opposed to using excessively high voltages. I am very concerned with this. You will note from my current testimony that I consistently refer to a variable voltage electron accelerator. This may or may not be that unit. We are going from zero to I don't know how many volts to find out whether electrons as opposed to cobalt 60 sources are an appropriate means of either sterilizing or pasteurizing foods. I think I can speak for the AEC when I say that in this area as a research tool they believe this is sound and proper. Is that correct, Commissioner Floberg?

Mr. FLOBERG. Yes; we think it has a useful application as a research device.

Chairman ANDERSON. Of course, this does not hurt Varian Associates; does it? How we happened to get the copy is the fact that in the January hearing somebody testified you had it—Dr. Herman Kraybill testified before us and first brought this report to the committee's attention. This was on January 15. We did not know it existed. So we asked for a copy of it at the January 15 hearing.

On March 16 we got a copy. I assure you that the acquiring of it was legitimate, even if the document was not finally approved.

(The correspondence between Mr. Morse and the Joint Committee regarding the December revised program follows:)

FEBRUARY 26, 1960.

Mr. RICHARD S. MORSE,
Director of Research and Development, Department of the Army,
Washington, D.C.

DEAR MR. MORSE: This will confirm the telephone request of Mr. John T. Conway, assistant staff director, Joint Committee on Atomic Energy, to Dr. John L. Schwab, your special assistant, on this date, for a report pertaining to a modified version of the Army Food Irradiation Center referred to during the Joint Committee's hearings on January 15, 1960, and which Congressman Melvin Price had requested.

You will recall that Dr. Herman F. Kraybill, senior scientist, Nuclear Radiation Department of the Curtiss-Wright Corp., who was former deputy project leader in the Office of the Surgeon General, Department of the Army, in testifying before the Joint Committee, first brought this report to the committee's attention. Dr. Walter M. Urbain, director of engineering research, Swift & Co., and Chairman of the National Research Council, Subcommittee on Radiation Preservation, also made reference in his testimony before the Joint Committee that same day to a decision by the Army for a smaller facility.

Representatives of your office were present during the hearing when Congressman Price stated that the committee would ask for the report. I, that same day, spoke with your special assistant, Dr. Schwab, and, on behalf of the committee, requested the report. I would appreciate it therefore if, in accordance with the committee's wishes and my request of January 15, that the report be furnished to the Joint Committee.

Sincerely yours,

JAMES T. RAMEY, *Executive Director.*

DEPARTMENT OF THE ARMY,
OFFICE OF THE DIRECTOR OF RESEARCH AND DEVELOPMENT,
Washington, D.C., March 16, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
The Capitol, Washington, D.C.

DEAR MR. RAMEY: I regret the delay in responding to your request of February 26, 1960, for the Army's report on the modified version of the Army Food Irradiation Center referred to during the Joint Committee's hearings on January 15, 1960.

Enclosed herewith is a copy of the proposed revised Army program as submitted by the Quartermaster General for approval and referred to in the January 15 hearings. Since its submission to the Army staff in early December, it has been reviewed and modified. The program, as finally approved in my office on March 11, is attached as enclosure 2.

Sincerely,

RICHARD S. MORSE,
Director of Research and Development.

Representative VAN ZANDT. I would like to go back to the General again. What is the status of this report that you are waiting on now as far as the location of an accelerator at Natick is concerned?

General CALLOWAY. We received the directive yesterday and will start it as soon as we complete our work here and are back at the office to do so.

Representative VAN ZANDT. You received a report yesterday?

General CALLOWAY. A directive yesterday to make a study.

Representative VAN ZANDT. Starting to make a study?

General CALLOWAY. Yes, sir.

Representative VAN ZANDT. You anticipate making a decision soon?

General CALLOWAY. We anticipate submitting a recommendation and a study to the Office, Chief of Research and Development.

Representative VAN ZANDT. This decision when made could not be implemented, however, until approved by the Armed Services Committee; could it?

General CALLOWAY. I am not certain of that.

Mr. MORSE. There may be some confusion here, if I may suggest it. We have two distinct problems which do not bear relation to each other. The decision of the Quartermaster General or his wishes to concentrate his research and development activities under one command which I think makes sense economically and managementwise, has nothing to do with the accelerator or our activities in the food irradiation field. The two are completely separate. The Food and Container Institute, it was never contemplated that we conduct food irradiation work there, or if it was, it was abandoned. As far as the research facilities go, I don't believe—I may be on thin ground here—that we need any approval from anyone other than Dr. York's office, which we now in fact have. These are just research instruments. It does not involve a massive structure. We are not talking of a big building or moving people from Chicago. It is an entirely different program. One of the aspects of this study which the Quartermaster Corps is about to make would involve close coordination with the Atomic Energy Commission, with other departments of the Government, to make certain that we have an orderly program existing within the country as a whole and not just the Army program. It is

that kind of study plus the cost of completing this accelerator or buying a cheaper one that they intend to do.

Representative VAN ZANDT. I must confess, Mr. Morse, if you decide to locate the accelerator at Natick, it will influence my decision regarding Chicago.

Mr. MORSE. Why?

Representative VAN ZANDT. My thinking is that the accelerator will play a very important part in the research effort of the Quartermaster General for tomorrow and the next day.

Mr. MORSE. I don't quite follow that. This is merely a research tool to conduct research. It does not involve a pilot plant or production.

Representative VAN ZANDT. The Quartermaster General has decided to concentrate all of his research activities at Natick; is that not correct?

Mr. MORSE. That is correct.

Representative VAN ZANDT. The House Armed Services Committee has been called upon to make a decision regarding a certain phase of this research effort; isn't that correct?

Mr. MORSE. This is in connection with the military construction appropriation?

Representative VAN ZANDT. That is correct. If the decision to locate the accelerator at Natick is made, as I see it, there is nothing else left for the House Armed Services Committee to do but to go along, because of the value of the accelerator.

Mr. MORSE. The value of the accelerator bears no relation to the value of the operation at Chicago.

Representative VAN ZANDT. I am talking about the overall effort to establish a general research center at Natick.

Mr. MORSE. This is precisely what we want to do.

Representative VAN ZANDT. Exactly.

Representative BATES. That is what you should do.

Mr. MORSE. That is exactly what we should do in the interest of good management. It is my job as far as management goes, it may be yours as far as funding.

Chairman ANDERSON. I can understand Mr. Bates rendering a judicial opinion that this should go in his district. I want to venture that Mr. Price will have a different opinion about moving it from Chicago.

Representative BATES. I think in the national interest it should be sent to the cultural, scientific, and educational center of the world.

Chairman ANDERSON. It is a very high-minded attitude and we appreciate it.

Representative BATES. Exactly as the Army recommended.

Mr. MORSE. The Army Quartermaster Corps has been trying to centralize its research and development activities at Natick for a good many years. I didn't mean to get into this subject, but I can reflect the Quartermaster's views, from the management point of view this makes sense. The character of the activities in Chicago have changed; 85 percent of the work they do is subcontracted. They are in an old building and essentially what we are doing is paying overhead for a rattletrap which the General Services Administration can no longer support. This is a hard way to do effective research with the amount

of dollars we have in the Army. That is the reason it should be moved and centralized in Natick.

Representative BATES. It is an economy and efficiency move.

Mr. MORSE. And management.

Representative VAN ZANDT. We are scheduled to go to Chicago this weekend but canceled the trip due to our awaiting a report from the GAO.

Mr. MORSE. I understand that the report has been completed and generally substantiates the Quartermaster General. With the same order of savings the GAO feels this is a sound thing to do for the country.

Representative VAN ZANDT. The report has not been submitted to Congress, as yet, has it?

Mr. FOSTER. The GAO has not rendered their report. We understand that they have had their final interviews with the Army people in Chicago. They completed their work at Natick some weeks ago. They are shooting for a completion date of about the 15th of April.

Representative BATES. Mr. Foster, in the event this accelerator requires a structure, then it would be necessary to get the approval of the Armed Services Committee for the structure?

Mr. FOSTER. Not necessarily, Mr. Bates. There is provision in law for supporting construction, brick and mortar, for research facilities using research and development funds. It would not come up in the military construction authorizing bill to which you refer.

Representative BATES. You better take a little look at that. I am glad to get that information. I can understand a small structure. When you get into an elaborate structure, it seems to me it ought to fall in line with every other structure that requires the specific authorization of the Armed Services Committee.

Mr. FOSTER. I am not informed as to the size of this facility. It has not yet come to my people in Installations. I understand it is very minor. The main cost is in the equipment. Perhaps the Quartermaster can speak more accurately to that point.

Mr. MORSE. May I continue?

Chairman ANDERSON. Proceed, please.

Mr. MORSE. Two, a flexible 1-million-curie cobalt 60-gamma irradiator.

Three, minimal associated food preparation and laboratory facilities.

A site survey committee will be appointed to make recommendations concerning an appropriate site for this research facility. Approximately 90 percent of the $1.3 million expended to date for design and components of the original pilot production plant will be adapted for use in the new research facility. The new facility will be completed at an additional expense of approximately $1.8 million. It is planned that the new facility will be operational in about 2 years. The services of this facility will be made available to other interested agencies.

Research emphasis will be placed on high dose sterilization of foods of prime military importance which have shown promise as a result of the Army's food irradiation research activities conducted over the past 6 years. Since many of these foods are important to the national and international economies, this research will support the President's atoms-for-peace program.

The revised program, which will continue to be administered by the Quartermaster General, is designed to insure an orderly resolution of unresolved research problems and to facilitate the earliest possible transition to industrial production. This program was coordinated with the Atomic Energy Commission; Food and Drug Administration; Committee on Radiation Preservation of Food—National Research Council; the Surgeon General of the Army; Departments of the Air Force and Navy; Marine Corps; and Continental Army Command—copies of this program were also made available to your committee.

In my opinion, this revised research program is a sound approach to the problems that must be solved. The Army will continue to make major contributions to basic knowledge which will ultimately make possible the final determination concerning the role of radiation processed foods in the national and international economies.

The Army welcomes assistance in this effort and we are particularly pleased that other agencies have recently announced plans to participate more actively in the advancement of this effort.

The Army will continue to cooperate with the Interdepartmental Committee on Radiation Preservation of Food and its member agencies, as well as with industry and other interested parties.

The Army appreciates the opportunity to present its revised research program on irradiated food to your committee.

Chairman ANDERSON. Mr. Morse, when you testified before us in January, the President's budget contained only $500,000 for research and development funds for irradiation and preservation of food. Was that the amount recommended by your Office?

Mr. MORSE. That was in the final budget.

General ELY. We went to the Department of Defense with an objectives budget of $1,265,000, which is what the Quartermaster recommended. As a result of the adjustment of funds and cutbacks within the Department of Defense, we ended up with $500,000 in the President's budget. We intend, in the Office of Chief of Research and Development, to supplement this with an additional $500,000 as soon as we receive the fiscal year 1961 appropriation. This supplementary fund will be made available from a reserve of funds that we withhold.

Mr. MORSE. This will be reprogramed within the Office of Chief of Research and Development.

Chairman ANDERSON. What did the Director of Research and Development recommend?

General ELY. Initially we had in our program $1,265,000.

Chairman ANDERSON. I know. I am moving from that program to what the Director recommended. Did you recommend $500,000?

Mr. MORSE. I don't think I specifically recommended any number. That is not quite the way we operate. This number was prepared by the Army staff and I concurred in it, if that is what you mean.

Chairman ANDERSON. Is there great military need for this development of the process of preserving food by irradiation?

Mr. MORSE. I see no urgent military need. I use the term "urgent" in the sense of necessity from the point of view of winning or losing a battle. If we could develop a radiation process for foods which was economical and the food tasted good, this would improve our

logistical problems and enable us to transport foods and have them more readily available, particularly in limited war, and this would obviously be advantageous to the military services.

In the sense of urgency, this is certainly not urgent compared with many other problems we have in the Army today.

Chairman ANDERSON. Perhaps our difficulty was that I used the term "great military need" and you used the term "urgent military need." I used the term "great military need" because General McNamara says analysis of actual experience in previous wars and the concepts of modern combat reveals a great military need for the development of a process of preserving food by ionizing energy. I use his term. Do you think there is a great military need for it?

Mr. MORSE. Again, Senator, I cannot interpret "great" until I know what it would cost to do it, and the extent to which we can improve packaging and have a logistical advantage. We certainly would like to serve the troops higher quality food. We would like to get it to them further into the zone of fighting than we are able to do at the present time. However, if the costs are exorbitant and when the food arrives it is as poor as some of the current irradiated food tastes, I see little need for irradiated food. We are hopeful through this research program we can solve the problems of taste, odor, wholesomeness, and to determine whether it is economical. If we are successful, it certainly would be a great advantage to the military. This is not easily seen at the moment.

Representative VAN ZANDT. Mr. Secretary, my mind goes back a few years and recalls testimony before the Price subcommittee which proved the need of irradiated food for what was then called, and I think is still called today, the atomic soldier. I recall it was mentioned that the atomic soldier of tomorrow would carry irradiated food. Beef was referred to, chicken, and so forth. I think the information came from Dr. Siu and his associates.

Dr. SIU. I believe so, sir.

Representative VAN ZANDT. They were speaking for the Army Quartermaster General at that time, and I would like to know what has happened between then and now to the program?

Mr. MORSE. The process does not work.

Representative VAN ZANDT. It doesn't work?

Mr. MORSE. That is right. We all hope it will and we are going to continue research to endeavor to determine why it doesn't work. We do not at the moment have a process which is economical and solves the problem of wholesomeness; and we do not have a product at the present time which I would feed the soldiers.

Chairman ANDERSON. Doesn't it vary?

Mr. MORSE. It varies a great deal. I refer particularly to chicken, beef, and pork, which constitute the main items for the Army in terms of dollars.

Representative VAN ZANDT. The basis of your statement that it doesn't work is related to the finding of one, a Dr. Monsen?

Mr. MORSE. No. He is one of the men who is a contractor and medical doctor who has been concerned with one aspect of the medical anomaly about which we are worrying. The process is not his field. It is the potential red flag that came up because of some serious medi-

cal questions. I would be glad to have Dr. Youmans bring you up to date on that.

Representative VAN ZANDT. Was that not the A. D. Little report? (See pt. 1, p. 571.)

Mr. MORSE. A. D. Little was one of several people who were asked from time to time to review the economics of the process, not the medical part of it. You have a copy of that, I believe.

Representative VAN ZANDT. I think someone was here as a witness in January and discussed Dr. Monsen's work.

Mr. MORSE. Dr. Nongesser was here.

Representative VAN ZANDT. Who else has advised that irradiation of food was not practical for military purposes?

Mr. MORSE. Practical is a matter of degree. It is not currently practical. If we didn't ever think it would be practical we would stop working on it today. I hesitate to quote people, but I have talked with the actual contractors associated with this program who, I think, had the most to lose in terms of dollars, and they concurred in the decision not to proceed at this time.

Representative VAN ZANDT. May I ask a question of Dr. Siu?

Chairman ANDERSON. Yes. I would say this, if I may. You mentioned several reports on the economics. The only report we have ever seen is this A. D. Little report that cost about $8,000, and was done in a couple of weeks. If you have other reports, we would like to see them. Do you have some question about the Little report?

Mr. MORSE. What type of report?

Chairman ANDERSON. You mentioned a moment ago you had several reports dealing with the economics. I say the only report we know about is the Little report. What other reports do you have?

Mr. MORSE. We have a large volume of reports on the medical side.

Chairman ANDERSON. Economics. That is what you mentioned, I think the record will show.

Mr. MORSE. When Mr. Van Zandt was referring to Dr. Monsen, that area of work is all medical.

Chairman ANDERSON. Did you have other economic reports? If you do, I would like to see them.

Mr. MORSE. I have not seen any formal one since I have been here.

Representative VAN ZANDT. Dr. Siu, when you appeared before us over a period of several years, did not, at that time, a military need exist for this type of food?

Dr. SIU. Yes, sir.

Representative VAN ZANDT. Did you not testify—based on laboratory tests—that the irradiation of food was practical?

Mr. SIU. Yes, sir.

Representative VAN ZANDT. And certain problems had developed, and through further laboratory work you hoped such problems would be eliminated?

Dr. SIU. Yes, sir. May I amplify a little bit? I think this is a difference of perspective and judgment at any given time. I have the tendency of looking at a bottle and seeing how much it is full. We started with an empty bottle of knowledge in this field. That was 5 years ago. I see that bottle continually being filled with knowledge. As we progress, I have felt that we were making progress toward the

time that everybody will be satisfied that it will be practical. I have been encouraged by that progress, and we reported this progress from time to time. This does not mean the bottle is full as of now. Otherwise we would stop the research program. I want to give you the feeling of a trend.

Representative VAN ZANDT. What about this atomic soldier who was to carry irradiated foods? While they were not preserved indefinitely, yet they were preserved for a reasonable time. Is this program a thing of the past?

Dr. SIU. No, sir. I think everybody in the Army agreed pretty much on this. I think there might be some misinterpretation. Everybody agrees that if the food irradiation process can be perfected, it would be fine for the Army. The difference here at any given point is what are the odds that you are going to perfect it, and this is where the difference of opinion exists. I do not believe there is any difference of opinion existing in the Army on the value of irradiated food if it can be successfully developed. Am I misquoting?

Mr. MORSE. No.

Dr. SIU. There is unanimity. This comes back, then, to the question of how irradiated food, if successfully developed, can be used in what you call the atomic soldier. If I may be excused by the uniformed members of the Army team because I am not a knowledgeable person in tactics, I will venture forth. There are several aspects.

One, as we envision it in the modern warfare, is the high demands on a soldier for alertness. I mean electronic equipment is complicated. The precision requirements are higher. So the influence of the environment on this man's alertness bears a very high value. One of the greatest influences is the food, the quality of the food. You could see it from your own experience. It depresses one's morale and alertness. This degree of alertness in modern warfare must be offset by the quality of the environment. That pertains to the psychic factor.

Another factor which is always important in past wars and future is the logistical load. We feel that the man in the front should have ready-to-eat meals that are palatable, that must be eaten cold. The most undesirable part of the current ration in the military is the meat item which, because it is thermally processed, is not as high value as we can have it. There is every indication from our progress to date that the irradiated meat component can be substituted for that with an exceedingly higher quality. So we feel that man at the front in actual battle can have a high quality meal to sustain himself.

Now, in the support area, where you do not have intensive fighting—this includes in the atomic submarines which are on long cruises—this means that you want to decrease the logistical load. People in the Navy tell us that if they can get rid of the refrigerator this would mean a lot because you pack more fighting armament. We feel that is within a reasonable expectation.

So all in all, just to give you two examples, we do feel that this has a great military need if it can be developed. Our estimate is that it can be developed.

Representative VAN ZANDT. Thank you, Doctor.

Representative BATES. Mr. Morse needed concurrence with the earlier statement of Dr. Siu. I don't know exactly what he agreed with. The doctor indicated that this would be perfected, it would be fine, and then he expanded his remarks a little bit. I wonder what you had in mind when you nodded concurrence? This would involve economics?

Mr. MORSE. Yes, sir.

Representative BATES. As I recall your prior testimony, it was your judgment that this is not economic.

Mr. MORSE. At the present time. I believe Dr. Siu said if we had a practical process it would be good for the Army, and in the sense of practical I refer to Food and Drug approving this, and at the moment it will take 3 years, I suspect. I include tasting good. I include being absolutely certain that our current anomalies found in animals are resolved, and I hope they will be. Additional research will show economics. By that I mean that the industry is willing to go into this and produce meat for the Army. If you solve all those things, then this is good and the Army needs it and can use it. It certainly is not urgent in terms of the many other problems we have. I am speaking specifically of things like defense and modernization of Army and I can go on with a long list of things which are far more important than this as far as my office is concerned.

Representative BATES. I wanted to get that explained.

Mr. MORSE. It includes all of those facets.

Representative BATES. When we had our hearings last time, it was indicated that the evidence on the medical tests was inconclusive, as I recall. The doctor who conducted the test indicated that he himself would eat the food. I wonder since our January hearings if there has been any new medical development? Perhaps Dr. Youmans could comment.

Dr. YOUMANS. I can't say there have been any striking new developments. We have proceeded with our program. The work which was reported by Dr. Munson has begun in another laboratory, and expanded to answer certain of the problems which could not be answered by his designed experiment. He himself is continuing his work. He is continuing to get some of the changes which he observed before. We are extending the work with dogs, which we discussed last time. The problem of the hemorrhage of rats has been quite satisfactorily resolved, I believe. If you will remember the blindness which was not blindness but congenital effects, has been satisfactorily explained.

Representative VAN ZANDT. Did you say it was resolved?

Dr. YOUMANS. Essentially, yes.

Chairman ANDERSON. How? What did you find out?

Dr. YOUMANS. By an explanation of what the mechanism is so it can be guarded against. It can be corrected.

Representative VAN ZANDT. At this particular point, would you refresh our mind as to the problem concerning the rat, and when was it resolved?

Dr. YOUMANS. When the rat was given irradiated beef he developed a tendency to hemorrhage. Since the testimony, although it was pretty clear then, we have pretty clearly resolved the fact that it is

due to an interaction which either prevents or uses up vitamin K. It can be resolved by adding vitamin K.

Chairman ANDERSON. So it is not a serious objection at all.

Dr. YOUMANS. Not now after we know the explanation.

Chairman ANDERSON. It was reasonably well known then. It was a tremendous obstacle then, It was higher than the Capitol.

Mr. MORSE. I don't think Dr. Youmans is through yet. There were four anomalies. I think he is trying to explain these one by one.

Chairman ANDERSON. Yes, that is one of them. What are the others?

Dr. YOUMANS. I mentioned the others and did explain them, I believe. I don't believe there is a great deal of expansion of our knowledge since last December. It has become more clear. If there are any remaining doubts, I think they will be resolved at the completion of our current study.

Representative BATES. I was trying to determine, Doctor, just what are the outstanding medical problems right now that have not been resolved. You had several problems involved, hemorrhage, sterility, et cetera. What has been done to resolve them?

Dr. YOUMANS. Mr. Morse, I am sure, would like to have me discuss this further, because he indicated that he does not want to leave the impression that all the problems are solved. They are not.

Representative BATES. That is the reason I am asking the question.

Dr. YOUMANS. The observations made by Dr. Munson have not been resolved. They are the enlargement of the heart and rupture which results in mice when fed certain irradiated food. The problem of sterility of the dogs has not been resolved. That still remains, although again, as I have said, additional experiments are being conducted in an attempt to solve the problem. I am quite sure that the problem with regard to the congenital absence of eyes has been solved because of the knowledge that occurred in a certain experimental animal involved, the strains which were used. The matter of the hemorrhage I have already discussed. There have been some changes in enzymes but they are on both sides of the fence. They are not consistent. In some species they occur in one way and in another species in another. Those are all problems which still must be solved in our program which, we testified last year, is expected to extend to December 1963.

Representatives BATES. Has it been absolutely established that these causes have come about by either irradiated food or might it be something unrelated, a diet problem or something along that line?

Dr. YOUMANS. In my opinion, neither one has been established as being actually due to irradiation per se. As long as doubt remains, the problem must be continued to be worked on.

Mr. MORSE. Mr. Chairman, I believe Colonel Hursh briefed your staff in detail yesterday, and we have submitted it to the staff, and I will give it for the purpose of the record, a fairly detailed summary of all of these kinds of studies and the kinds of medical effects we are looking at. This is a big program. I think it is probably the biggest wholesomeness study the country has ever undertaken. There is something like 250,000 animals that have been subjected to irradiated food, or we will say half are controls and half irradiated food. It is a tremendous job. You have to section the animals and then examine

the organs. We have not in some instances begun to look at the second and third generation facts. I don't think we are trying to run it into the ground. When these four red flags came up when I took over in June, it certainly made me pause for consideration before we built a plant. We are trying to solve these one by one as fast as we can. It is not something you do overnight.

Chairman ANDERSON. May I just ask one more question? On page 38 of the hearings printed in January, Congressman Westland asked some questions about logistics. He asked if the A. D. Little Co. would be doing any more work in that field, and was told they would not. He asked if they made an analysis of the logistics problem and your reply was they had been directed. Has any more work been done in that field yet? I don't want you to read the whole testimony. It starts on page 37 and then the top of page 38. Mr. Westland was asking about the study of the Arthur D. Little Co. as to whether there was greater flexibility of transportation, less rigid scheduling. Is it your intention to have this firm continue its study with those factors in mind and make a report to you? You said "No." The reason was that you said:

> I would say in that area the Quartermaster Corps and operations people within the Army would be more competent to make an analysis than Arthur D. Little.

Representative Westland said:

> Have they made an analysis?

and your reply was:

> They have been directed to.

I am wondering how that analysis has been coming along? Is it ready yet?

Mr. MORSE. No, sir. I refer you to one of your first questions today, this $80,000 in red, which is precisely for that purpose. That will be undertaken by the Chief of Research and Development as he deems fit.

Chairman ANDERSON. To tie the previous testimony to this?

Mr. MORSE. Yes, sir.

Chairman ANDERSON. Thank you. Are there additional questions?

Representative VAN ZANDT. Mr. Chairman, could we put chart 2 on the easel again?

Mr. Morse, the aggregate total for the period 1961–66 is $5,130,000, is that right?

General ELY. That is correct, on both charts.

Representative VAN ZANDT. This program started in 1953 and including 1960, we spent approximately $13 million, is that correct?

Mr. MORSE. Yes, sir.

Representative VAN ZANDT. By this schedule of expenditure for the period 1961 to 1966, does that mean with the expenditure of $5.130 million we will have something to show in the year 1966?

Mr. MORSE. That is our hope.

Representative VAN ZANDT. Using Dr. Siu's expression, do you think that the bottle will be full at that time?

Mr. MORSE. I am afraid in research the bottle is never full. That is the trouble. By that time technology will have been changed and we will probably be using some kind of radiation we have not thought of today. That is not our intent. I don't mean to be facetious. We

are hopeful we will have an orderly program to resolve these current difficulties and at least one or more products will be available for the Army or the civilian population.

Representative VAN ZANDT. Could you accelerate this program by spending more money?

Mr. MORSE. No, sir, I don't think so. You can always do things better and faster. I think this is an orderly program. Would you concur in that, General Ely?

General ELY. Yes, sir, I would concur.

Mr. MORSE. We have a Food and Drug Administration problem, for example, which just takes time, as these animal studies do.

Chairman ANDERSON. Could you furnish us with a chart as to what the program was as of July 1, 1959, and what the planned program is now? Don't you have a chart here that shows that?

Mr. MORSE. We have some handouts that perhaps you would like for your own use.

Chairman ANDERSON. May we have that for the record? In the first column—chart 1—you have "Research and engineering," $1,100,000, "Wholesomeness," $1,175,000, a total of $2,275,000. Is that comparable to the $1,080,000 figure in the first column of the research and development budget chart (chart 2)?

CHART 1.—*Radiation preservation of food—Planned program as of July 1, 1959*

	Fiscal year			
	1960	1961	1962	1963
Research and engineering	$1,100,000	$1,100,000	$1,100,000	$1,100,000
Wholesomeness	1,175,000	950,000	650,000	450,000
Total (excluding USAIRC)	2,275,000	2,050,000	1,750,000	1,550,000

CHART 2.—*Army, March 1960, revised irradiated food program—Research and development budget*

	Fiscal year					
	1961	1962	1963	1964	1965	1966
Military applications and economic analysis	[1] $80,000				$50,000	
Assurance of wholesomeness	300,000	$250,000	$200,000	$100,000	50,000	$50,000
Pre- and post-irradiation studies	340,000	340,000	340,000	440,000	320,000	250,000
Destruction of microorganism	90,000	80,000	60,000	50,000	25,000	25,000
Nuclear effects on foods	40,000	40,000	40,000	40,000		
Acceptance testing				35,000	60,000	60,000
Packaging studies	50,000	50,000	50,000	100,000	75,000	50,000
Radiation services	180,000	180,000	180,000	180,000	180,000	180,000
Total	1,080,000	940,000	870,000	945,000	760,000	615,000
Aggregate total	$5,130,000					

[1] Military logistic study to be funded by the Army Research Office.

CHART 3.—*Radiation preservation of food program—Actual funding, fiscal years 1954–60*

	Fiscal year						
	1954	1955	1956	1957	1958	1959	1960
Research and engineering	$672,000	$1,047,000	$1,588,000	$1,094,000	$1,180,000	$1,039,000	$1,175,000
Wholesomeness			154,000	1,206,000	1,358,000	1,216,000	1,050,000
Total	672,000	1,047,000	1,742,000	2,300,000	2,538,000	2,255,000	2,225,000

CHART 4.—*U.S. Army Ionizing Radiation Center planned program*

Fiscal year	1959	1960	1961	1962	1963
USAIRC (less sources)	586,000	2,925,000	677,000		
Linear accelerator (Linac)	650,000	370,000	50,000		
Cobalt 60 source (Hifl)	2,500,000				
Operation of USAIRC (including food)			1,904,000	2,232,000	2,611,000
Total (USAIRC)	3,736,000	3,295,000	2,631,000	2,232,000	2,611,000

General ELY. Yes, sir; this is comparable. This plan, as you can visualize, was made somewhere back in fiscal year 1959. At that time we were thinking that the money required for resolving the wholesomeness studies would be something of this order. We now find we can continue the wholesomeness studies to satisfy with far less expenditures than we expected.

Chairman ANDERSON. I asked that because of the Army's press release of March 29, 1960, in which you say, "A revised 6-year $5 million program to accelerate research on specific irradiated foods for military use * * *." Standing alone without that explanation, it looks like you have gone from $2,275,000 down to $1 million, which is the reverse of acceleration. (See p. 759.)

General ELY. It would appear that way with the figures.

Mr. MORSE. Mr. Chairman, if I may refer to that question, the decision originally was to proceed with a considerably larger plant which was going to process a wider variety of products, fruits, vegetables, fish, on a pretty large scale. In my view, we are accelerating research because now we are going back and trying to find out some of the answers to the fundamental problems related to the mechanism of irradiation and what kind of research we need. So, while the dollars are lower, actually I would like to state for the record that this change in the program will save the taxpayers $15 million, and I think that is a good thing at this point. We are doing more research, but we are doing less brick, mortar, and construction than we would if we had proceeded at Stockton.

Chairman ANDERSON. The construction figure is something else. I am dealing with the research and wholesomeness total which is: As of July 1, 1959 (chart 1) you planned to spend $2,050,000 in fiscal year 1961, which in the March 1960 revision (chart 2) is reduced to $1,080,000. For fiscal year 1962, you were to spend $1,750,000, and that is now reduced to $940,000. I merely say on the surface it does not look like acceleration.

Mr. MORSE. That is correct. We are now concentrating on 4 food items as against 21.

Representative VAN ZANDT. Mr. Morse, this 6-year total of $5,130,000 on chart 2 shown there, is that Army funds alone? There is no AEC money in there?

General ELY. No, sir. This is entirely the funding that the Army would like to apply to this program as we see it at this time from the Army research and development.

Representative VAN ZANDT. Will this sum be augmented in any way by AEC money?

Mr. MORSE. Yes, sir.

General ELY. As we understand, the AEC program in the fiscal year 1961 will have something in the neighborhood of $500,000.

Representative VAN ZANDT. Does this program contemplate any nongovernment money being spent by participants such as the large packers and so forth?

Mr. MORSE. No, sir.

General ELY. I believe that Dr. Siu can probably give a better estimate of what they will continue to do in this program area than I can.

Mr. MORSE. This program here does not envisage industry spending its own dollars in integration with this program, if that is what you mean. We have tried to develop and working very closely and happily with the AEC resulting program, where we are not duplicating. They will emphasize the low dose determination. We will terminate some of our activities in that area, but finish those which are far enough along to make them uneconomical not to continue them.

Representative VAN ZANDT. Do you contemplate any projects being awarded to packers in the field of research?

Mr. MORSE. This is a normal procedure. This is not all done in house. This is contracted out. I don't know whether the packers specifically are working.

General CALLOWAY. Some contracts are no cost.

General ELY. Our revised program and our revised directive to the Office of the Quartermaster General directs that they make an effort to exploit this field.

Representative VAN ZANDT. Thank you.

Representative BATES. Mr. Morse, in your January statement, you indicated that closely supervised experimental feeding on human beings is necessary and warranted. Are you continuing such experiments?

Mr. MORSE. Not at the present time.

Representative BATES. You said at that time you were in agreement with the position of the Surgeon General with respect to such a statement. Do you recall your statement?

Mr. MORSE. No, sir, I don't recall that.

Representatives BATES. In your statement of January 14, you said, "We are in agreement."

Mr. MORSE. We have stopped all work now. Eventually we have to initiate short-term feeding experiments, if that is what you mean.

Representative BATES. But you do not recommend it at this time nor are you doing it at this time?

Mr. MORSE. That I believe is correct.

General ELY. This is reflected in our revised program. As you will notice, we have no funding of acceptance testing until fiscal year 1964.

Representative BATES. This 1965 figure, that will be Quartermaster money?

General ELY. Yes, it will be entirely Quartermaster money.

Representative BATES. What do you intend to do at that time? Refine the recommendation you made for the $80,000?

General ELY. This is a guesstimate into the future. It probably will be desirable to make a new analysis of some phase of the economics or some phase of the logistic activity.

Mr. MORSE. Engineering studies, perhaps.

Representative BATES. You hope at that time you will have $50,000. That is far enough away so it won't cause any problem for the moment.

Mr. MORSE. It is essentially correct.

Representative BATES. Even the Bureau of the Budget will probably go along with that.

Senator PASTORE. I notice on your chart under the category of assurance of wholesomeness that you start out in fiscal 1961 with $300,000, and then you gradually go down to $200,000, $150,000, and finally in 1966, $50,000. Are we to assume that there has been a breakthrough in this research program as to the assurance of wholesomeness that would warrant that less and less money would be spent for research in that particular category by 1966?

Mr. MORSE. All this is is the best estimate that we can make tied to past experience, particularly with regard to our current animal studies. We are trying to guess the period of time required to get the kind of data the Surgeon General is concerned about.

Senator PASTORE. There has been a lessening of effort in this particular field, and I think it is justified. I think the emphasis to persist with research and development is a very delicate and sensitive area. It involves people, I suppose, to find the right answers. I think half the world is frightened to death over this whole matter of radiation. But the question I would like to ask is this: Are we just pursuing this study for the exercise that is involved in it, or are we hopeful that something tangible and productive will come out?

Mr. MORSE. We certainly are hopeful. Otherwise we would not continue to research.

Senator PASTORE. Along that line, are we more hopeful today than when we started, or are we less hopeful today than when we started?

Mr. MORSE. I don't know exactly how I would answer that question.

Senator PASTORE. You start on the research of some project or another and as you go along, it becomes either more feasible in your judgment or it becomes less feasible. How do you feel about it by comparison of time?

Mr. MORSE. I think this is a question of what time you take and the gentlemen to whom you address the question. I personally am no more hopeful of this program than I was 5 years ago.

Senator PASTORE. You are more hopeful?

Mr. MORSE. I am not any more hopeful or less hopeful. I think we have uncovered in some areas difficulties which we did not anticipate. On the other hand, as Dr. Youmans has just pointed out, a couple of these anomalies in animals we have recently begun to find answers.

Senator PASTORE. I am not being critical. I hope you understand that.

Mr. MORSE. I don't know.

Senator PASTORE. This is a field that has intrigued me. I have talked on it in the past several times. I have been doing less talking because of all of the problems involved. There was one time when we would say we are going to preserve food one day without refrigeration. This is going to be a boon to mankind throughout the world, especially in those countries where they don't have the facilities of refrigeration that we have. Then of course it would be a great boon to the Army, I suppose, and that is the reason the Army is interested in it. You will admit that we have a hard row to hoe ahead of us in this particular field.

Mr. MORSE. Yes, sir; I would. I happen to have been personally in a small way associated with the atomic energy program perhaps longer than most people, dating back prior to the formation of the Manhattan District in 1940. I would say this program is about in line with most of the atomic energy programs of this country and the world. I was at the Geneva Atoms for Peace Conference myself. I was also at the Japanese international meeting. One tends to get very enthused about these things in the initial blush of scientific breakthroughs, in a similar manner to which many of our people are becoming space cadets in this country.

Senator PASTORE. I think it is good to include with that both deliberateness and calmness. I was a delegate to the United Nations in 1955 when the draft resolution was adopted. We were talking then in terms that within a year's time we are going to solve all the problems of the world with atomic energy. That has not happened.

Mr. MORSE. I am well aware of it.

Senator PASTORE. I do not think we have had many significant breakthroughs even with reactors. I am wondering whether or not this is more or less the same story with irradiation of food.

Mr. MORSE. I think it is about in the same general category as our reactor program. We are going to solve the problems and in the long run the world will benefit from them. But you don't do it overnight and you don't do it in the newspapers.

Senator PASTORE. And the emphasis should be on research and development and not constructing buildings and what have you.

Mr. MORSE. You don't push the state of the art so fast that you get trapped.

Chairman ANDERSON. May I just say, Senator Pastore, that we got an original Army Quartermaster Corps document on food preservation dated December 1959 which has since been revised. It was pointed out this is not an official document. It did have a summary on page 80 which said:

> **The Army has made excellent progress in the past 5 years in food irradiation. Despite the difficulties normally expected, in a pioneering effort of such complexity, and magnitude, the program has moved forward at a good rate. It is approaching practical realization. This is not to deny the problems still ahead, but no unresolvable obstacles are envisioned.**

When the revised document came out those last three sentences were deleted. So there is not just as much optimism as you might imagine.

Mr. MORSE. I took them out.

Chairman ANDERSON. I realize that.

Senator PASTORE. I think the country and the world is entitled to the truth. I don't think it is any reflection on anyone's effort.

Representative VAN ZANDT. Mr. Morse, will you refresh my mind on this accelerator? From the standpoint of completion, what is the situation?

Mr. MORSE. I am having a little difficulty in getting a fixed price from the contractor. I would say the current estimate the Quartermaster has, however—this is not what I call a firm fixed price—would indicate about an additional $130,000 to complete it, plus installation costs of approximately $270,000.

Representative VAN ZANDT. I am talking about the hardware now.

Mr. MORSE. 70 or 80 percent completed. But it has not worked yet.

Representative VAN ZANDT. That is true. When the decision has been made to locate the accelerator, can you give us some idea of the time necessary to complete the accelerator and install it?

Mr. MORSE. I think as I indicated in the testimony here it would be about 2 years before the facilities were in initial operation, starting from now.

Representative VAN ZANDT. So we could probably look to fiscal 1963.

Mr. MORSE. If we proceed as currently planned.

Representative VAN ZANDT. Thank you.

Chairman ANDERSON. Thank you, Mr. Morse.

Mr. Morse, I hope if we run into the afternoon that you would be back here this afternoon. I anticipate that a Congressman from Illinois may want to know about this move to Massachusetts. If you could be back, we would appreciate it.

Mr. MORSE. You would like me back at 2 o'clock?

Chairman ANDERSON. Yes.

Representative PRICE. Perhaps we could be reinforced by a Congressman from California.

Representative BATES. I hope, Mr. Chairman, that this decision will be based on the facts instead of being kicked around on the Hill.

Senator PASTORE. I have always said that the smoke of the factories from Rhode Island mingle with the smoke of the factories of Massachusetts. How close to Rhode Island are we coming?

(The prepared statement of Mr. Morse follows:)

STATEMENT OF RICHARD S. MORSE, DIRECTOR OF ARMY RESEARCH AND DEVELOPMENT RE THE ARMY REVISED RADIATION PROCESSED FOOD PROGRAM, MARCH 31, 1960

Mr. Chairman, gentlemen of the committee, I am Richard S. Morse, Director of Army Research and Development and have been designated to represent the Army today. I have supporting witnesses whom I would like to introduce to you:

Dr. John L. Schwab, special assistant to the Director of Research and Development.

Maj. Gen. C. C. Calloway, Deputy Quartermaster General for Operations, Office of the Quartermaster General.

Brig. Gen. Wm. J. Ely, Director of Army Research, Office, Chief of Research and Development.

Dr. R. G. H. Siu, Technical Director, R. & E. Division, Office of the Quartermaster General.

Dr. J. B. Youmans, Technical Director, U.S. Army Medical Research and Development Command, Office of The Surgeon General.

Col. L. M. Hursh, Chief, Medical Research Branch, U.S. Army Research and Development Command, Office of The Surgeon General.

In my previous appearance before the Joint Committee on Atomic Energy on January 14, 1960, I testified that, as a result of my investigation of the Army's food irradiation research program, I had suggested to the Army Chief of Staff that construction of a pilot plant at Sharpe General Depot, Stockton, Calif., be suspended indefinitely, and that the Chief of Research and Development, Department of the Army, prepare and submit a revised research program on radiation preservation of food stressing fundamental studies. This pilot plant was designed with food processing lines and radiation sources to sterilize approximately 1,500 pounds of meat per hour—operated on a 24-hour schedule, it would have been capable of supplying meat to approximately 30,000 troops.

The reasons which I gave for my decision to suspend construction of the pilot plant and to reorient the research program were:

(*a*) Lack of studies confirming any substantial economic advantage to the Armed Forces accruing from the use of irradiated foods.

(*b*) Lack of an urgent operational requirement.

(*c*) Evidence of animal anomalies resulting from the wholesomeness studies.

(*d*) Unsolved complex fundamental research problems requiring resolution prior to the initiation of large-scale operations. Typical of such are—

(1) Development of procedures for improving the taste, appearance, odor, and troop acceptability of irradiated foods, particularly beef—a high tonnage item.

(2) The identification of chemical changes in foods resulting from the irradiation process.

(3) Studies on the mechanism and procedures for controlling proteolytic enzymes.

(4) Studies on the mechanism of killing radio-resistant micro-organisms.

(5) Development of suitable packaging materials and procedures.

At the time of my previous testimony I had not received the revised research program which I had requested from the Chief of Staff. By memorandum dated March 7, 1960, the Vice Chief of Staff of the Army forwarded to my office a copy of the revised research program. On March 10, 1960, I forwarded the Army program to the Director of Defense Research and Engineering for his approval. On the same date I forwarded the approved plan to the Assistant to the Secretary of Defense (Atomic Energy). It is my understanding that copies of this correspondence and the approved program have been made available to your committee. I have copies of this correspondence and the approved plan which I should like to submit at this time for the record. On March 24, 1960 I received general program approval from the Director of Defense Research and Engineering.

Before discussing the revised program I believe it necessary to clarify two important points concerning the Army's program.

First, it has been suggested in some quarters that the Army has "dropped the ball" with respect to its effort in the radiation preservation of food-research field. The suspension of the construction of the pilot plant at Stockton, Calif., has been misinterpreted as indicating that the Army's program has been canceled. The facts are, that the Department of the Army has maintained, without interruption, an active research program from 1954 to the present—and is continuing an active research program.

Secondly, there appears to be a misunderstanding relative to the extent of the Army's interest in, and work on, the low-dose (pasteurization) radiation treatment of foods. The current Army program, while emphasizing research in high dose treatment (sterilization) of foods, has not neglected low-dose treatment (pasteurization). We have made significant contributions in the low-dose area. The Quartermaster General is preparing a detailed technical monograph on the work which the Army has accomplished in the low-dose treatment of foods.

The revised Army research program provides for an expenditure of $5,130,000 for fundamental research over a 6-year period (fiscal years 1961–66, inclusive). The research will be conducted under seven major tasks (chart 1):

(1) Military applications and economic analyses;
(2) Assurance of wholesomeness;
(3) Pre- and post-irradiation studies;
(4) Destruction of micro-organisms;
(5) Nuclear effects on foods;
(6) Acceptance testing; and
(7) Packaging studies.

To support this program it is necessary to construct a radiation research facility which will include—

(1) A variable voltage electron accelerator.[1]

(2) A flexible 1 million curie cobalt-60 gamma irridator.

(3) Minimal associated food preparation and laboratory facilities.

A site survey committee will be appointed to make recommendations concerning an appropriate site for this research facility. Approximately 90 percent of the $1.3 million expended to date for design and components of the original pilot production plant will be adapted for use in the new research facility. The new facility will be completed at an additional expense of approximately $1.8 million. It is planned that the new facility will be operational in about 2 years. The services of this facility will be made available to other interested agencies.

Research emphasis will be placed on high-dose sterilization of foods of prime military importance which have shown promise as a result of the Army's food irradiation research activities conducted over the past 6 years. Since many of these foods are important to the national and international economies, this research will support the President's atoms-for-peace program.

The revised program, which will continue to be administered by the Quartermaster General, is designed to insure an orderly resolution of unresolved research problems and to facilitate the earliest possible transition to industrial production. This program was coordinated with the Atomic Energy Commission; Food and Drug Administration; Committee on Radiation Preservation of Food—National Research Council; the Surgeon General of the Army; Departments of the Air Force and Navy; Marine Corps; and Continental Army Command—copies of this program were also made available to your committee.

In my opinion, this revised research program is a sound approach to the problems that must be solved. The Army will continue to make major contributions to basic knowledge which will ultimatley make possible the final determination concerning the role of radiation processed foods in the national and international economies.

The Army welcomes assistance in this effort and we are particularly pleased that other agencies have recently announced plans to participate more actively in the advancement of this effort.

The Army will continue to cooperate with the Interdepartmental Committee on Radiation Preservation of Food and its member agencies, as well as with industry and other interested parties.

The Army appreciates the opportunity to present its revised research program on irradiated food to your committee.

(Correspondence between the Joint Committee and the Department of the Army subsequent to Mr. Morse's testimony follows:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., June 3, 1960.

Mr. RICHARD S. MORSE,
Director of Research and Development,
Department of the Army, Washington, D.C.

DEAR MR. MORSE: As you know, the Joint Committee has been quite interested in the national food irradiation program, particularly in light of the Army's revised program. During the hearing before the Subcommittee on Research and Development of the Joint Committee on March 31, 1960, you discussed with the members the question of using the high capacity 24 million electron volts accelerator in the contemplated Army research center. It is understood that the AEC and the Office of the Surgeon General, Department of the Army, opposed the Linac high-voltage unit and that a detailed review was to be made to determine the desirability of using a less expensive electron accelerator more suitable as a research tool.

Your memorandum of March 28, 1960, to the Chief of Research and Development, Department of the Army, requested such a review and that a decision was to be rendered to you on this matter by April 20, 1960.

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[1] The linear accelerator was originally designed as a high-volume processing unit for installation at the Stockton facility. To date approximately $600,000 has been expended for design and partial fabrication. Although this unit is not ideally suited as a research unit, it is capable of being modified and completed to meet the needs of the research program. However, before final decision, a detailed review will be made to determine the desirability of using a less expensive electron accelerator more suitable as a research tool.

To date the Joint Committee has received no information as to whether or not the study has been completed and what decision has been made. Similarly, it has received no information as to the results of a study by the Quartermaster Corps as to the location of the site for the Food Irradiation Research Center. During the March 31 hearing General Calloway, Deputy Quartermaster General, testified that he had been instructed to commence such study on the day before the hearing.

It would be appreciated if you would advise the Joint Committee concerning the status of these two studies and furnish any additional information pertinent to the Army food irradiation program which will enable the committee to keep currently and fully informed concerning this project.

Sincerely yours,

JAMES T. RAMEY, *Executive Director.*

DEPARTMENT OF THE ARMY,
OFFICE OF THE DIRECTOR OF RESEARCH AND DEVELOPMENT,
Washington, D.C., June 22, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: In reply to your letter of June 3, 1960, regarding the Army revised irradiated food program, the following information is furnished.

A decision has been reached to modify the original Varian Associates 24 million electron volts pilot plant model, linear accelerator so as to produce a variable-energy electron source for research purposes per the following specifications:

(*a*) Provide 18 kilowatts power, O–24 million electron volts energy, 750 micro-amperas average beam current at 24 million electron volts;

(*b*) Omit magnetic deflector and scanner;

(*c*) Add a simple beam diffuser and a simple X-ray converter;

(*d*) Simplify conveyer to absolute minimum necessary for research purposes.

An analysis leading to this decision was conducted by Office, Chief of Research and Development and resulted in a finding of the need for a 24 million electron volts linear accelerator rather than the 12 million electron volts device included in the Army revised irradiated food program submitted to your committee at the March 31, 1960, hearings. As your committee knows, the past history of the Army's irradiated food research has brought forth several fundamental unsolved research problems. My review of the results of the above-mentioned analysis has convinced me that such a basic research tool is needed to support the fundamental research which is directed toward the solution of these problems. It is not the Army's plan to use this 24 million electron volts accelerator for irradiation of food to be fed to humans. It will be used solely as a basic research tool to assist in the solution of problems in the areas indicated below.

In the analysis leading to this decision, consideration was given to the economics involved and the equipment requirements for a research program on induced activity, dose-rate, dose-depth, enzyme and vitamin changes, food flavor retention versus sterilization, and electron versus high-energy gamma irradiation. The specified average beam current is based on dose-rate and flavor retention versus bacteria kill research requirements; the specified maximum energy is based on dose-depth and induced activity research requirements. The determination that the completion of the Varian Associates' instrument was the most economical approach to supplying the optimum electron research source was derived from comparisons of the costs of three courses of action. These were the possibilities of the modification of the original Varian pilot-plant device to provide a research instrument; the salvaging of the pilot-plant model and the designing and construction of a new instrument to research specifications; or the purchasing of an off-the-shelf accelerator.

A decision has not been made as to location of the site for the food irradiation research facility. As Major General Calloway previously testified, the Quartermaster General did receive instructions to appoint a site survey board. A board was appointed and it is expected that the approved recommendations of the Quartermaster General will be forwarded to the Department of the Army within the near future. When review at the Department of the Army staff level

is completed and a decision has been rendered concerning the site for the radiation research facility, your committee will be informed prior to any public release of such information.

You may be interested to know that since the March 31, 1960, hearing of the Joint Committee on Atomic Energy, the Army Research Office has initiated an operations research study to determine the logistic, operational, and economic advantages which would accrue to the Armed Forces through the introduction of foods treated by ionizing radiation into the military combat and peacetime ration. The study is to be conducted by the Operations Research Office, Johns Hopkins University, on a contract basis and is estimated to require approximately 9 months to a year for completion. I have enclosed, for your information, the proposed scope and objectives of this study.

Sincerely,

RICHARD S. MORSE,
Director of Research and Development.

PROPOSED SCOPE AND OBJECTIVES FOR OPERATIONS RESEARCH STUDY

Objective: To determine the operational, logistical, and economic advantages and disadvantages which would accrue to the Armed Forces through the introduction of foods treated by ionizing radiation into the military combat and peacetime ration.

Scope: This study will include but will not necessarily be limited to—

(*a*) A critical analysis of current concepts for the integration of irradicated foods into the combat feeding system of the Armed Forces.

(*b*) A determination of the present and future combat requirements from a tactical standpoint for irradiated foods. In this connection, both limited and general warfare situations should be considered. Combat requirements of the field army, battle group, Strac, and Marine Corps should be given special attention.

(*c*) A consideration of the logistical implications involved in the peacetime and combat use of irradiated foods as components of the military ration (i.e., cost, manpower, transportation, storage, preparation, etc.).

(*d*) A comprehensive analysis of the economic implications involved in effecting a transition to industry of production of irradiated foods, provision of an adequate mobilization base, and the impact on strategic storage concepts.

(*e*) A comparative analysis of the logistical, operational, and economic advantages and disadvantages to the military of irradiated foods as ration components versus freeze-dehydrated, dehydrated, frozen, and heat-processed foods.

(*f*) A determination of the relative urgency of the operational requirement for irradiated foods as compared to the operational requirements for improved weaponry, individual and group protection, transportation, other improved foods, communications, medical care, etc.

(*g*) Consideration of the current technical "state-of-the-art" and technical potential for meeting the time frame objective set forth in reference (*b*) (1965–75).

(*h*) Consideration of the R. & D. investment in funds to date and probable future expenditures required to achieve program objectives as compared to the magnitude and significance of payoff for the Armed Forces expressed in terms of logistic, operational, and economic requirements or improvements, morale, efficiency, or other benefits.

(*i*) Recommendations.

STATEMENT OF HON. HERBERT B. LOPER,[1] ASSISTANT TO THE SECRETARY OF DEFENSE (ATOMIC ENERGY)

Chairman ANDERSON. General Loper, one of the reasons you are here is because of your letter which says, "however, final approval of reprograming of funds required to support the program has not yet been granted."

So these charts that are here that show a million dollars have not yet been approved; have they?

[1] The full prepared statement of General Loper appears on p. 708.

General LOPER. The final approval of the Secretary of Defense and the action of the Comptroller have been completed. I think actually General Ely may be a little closer to that than I am. I was trying to get the latest information on that this morning. I don't know that I have anything any later.

Chairman ANDERSON. I understand this question arose if these anticipated expenditures have any validity because as I understand it, they have not yet been approved. Isn't that correct?

General ELY. You are speaking of the figures for the research program?

Chairman ANDERSON. Yes; the million dollars that was up there on the board this morning, $500,000 is all that has been approved.

General ELY. $500,000 has been approved by the Secretary of Defense, and we are authorized within the Office of the Chief of Research and Development to reprogram some reserve funds that we have for something of this nature.

Chairman ANDERSON. But as I understand it, you have not done so yet?

General ELY. This is the fiscal year 1961 program. We don't have the appropriation yet. When we have the appropriated funds, then we will take the necessary reprograming action to make the funds available.

Chairman ANDERSON. What about 1960?

General ELY. There is no problem in fiscal year 1960 funding.

Chairman ANDERSON. Go ahead, General.

General LOPER. The part I was speaking about, Senator, had to do with the remnants of the funds which were transferred to the Atomic Energy Commission for the completion of the facility at Stockton. These funds still remain with the Atomic Energy Commission and the approval of the Director of Research and Engineering, who is the original source of those funds, for the utilization of those funds for the new program has been obtained. But the final transaction of withdrawing the funds from the Atomic Energy Commission and reallocating them to the Quartermaster General has, so far as I know, not been completed.

I was asked to make a very brief statement with respect to the interest of the Department of Defense in food irradiation. In conjunction with its responsibility for single managership for subsistence for the Department of Defense, the Department of the Army has been conducting research in the field of food processing. This effort has included the field of preservation of foods by irradiation. Witnesses from the Department of the Army have given you the status of the program and background data, so I will confine my remarks to a brief statement of the interest of the Department of Defense in the food irradiation process.

The Department of Defense is greatly interested in food processing procedures which offer promise of improving the quality of foods for the Armed Forces. Improved quality and variety are particularly important under conditions where the Armed Forces may be subjected to abnormal hazards and discomforts for long periods of time. Food irradiation appears to offer possible means of substantial improvement.

The aim of the 5-year program initiated by the Quartermaster General in 1953 was to more adequately satisfy the continuing requirement of the Department of Defense for an adequate and wholesome supply of food for its fighting forces. This requirement extends itself into several areas. Among these are light weight, palatability, wholesomeness, storage without refrigeration, minimal storage space, preparation time, preparation equipment, and trained personnel for preparation. Since the current operational rations fall short in one or more of the above, the field of irradiation of food was and is being examined as a possible means of improving logistics of troop subsistence.

The present standard feeding situation in the services when stable and static conditions exist, and manpower, cooking, and refrigeration equipment are available, may be improved by reducing one or more of the above areas.

Small, mobile, dispersed units of the Army and those operating in forward areas require operational rations in a variety with considerable improvement in taste and acceptability over those currently available. Manpower, money, and equipment can be saved by a capability to supply freshlike food requiring no refrigeration.

The development of the long-range atomic-powered submarine possibly represents the best example where improvements in subsistence are vitally needed for the Navy. However, vast savings may be possible in all ships if partially prepared, easily packaged, wholesome, and palatable rations can be provided.

The problem of providing food for the crew members of long-range, high-altitude aircraft of the Air Force is apparent. This problem would be considerably increased in space flight.

The Department of Defense is particularly interested in radiation processing as a means of improving subsistence for the fighting forces for the above and other vital situations. However, it is expected that if the Army's research program contributes to improving preservation and packaging procedures for food, the public at large will benefit as it always has from research and development efforts of the military services in areas that can be applied to civilian use.

I might add very briefly to that, that at the Department of Defense level, the program has been examined from time to time by the Director of Research and Engineering, and his predecessor, the Assistant to the Secretary of Defense for Research and Engineering, and on each occasion it has been endorsed by that Office. I think one of the most striking examples of his endorsement and enthusiasm in support of this program has been the decision to allocate $2½ million for the initiation of the development of the Stockton facility from the emergency funds which were available to the Director of Defense Research and Engineering. Any time one gets that much money out of the D.D.R. & E. emergency funds, you can be quite sure the Director is sold on the objectives of the program being supported.

That concludes my statement, Mr. Price.

Representative PRICE (presiding). Thank you very much, General. In your statement you did not use the words "accelerated program."

General LOPER. No. I question whether this is an accelerated program. I think what Dr. Morse has said here, that acceleration if applied to the present program, is an acceleration over what it would

have been if they had maintained an interest and research program dealing with 21 varieties of food, rather than limiting it to the most important and applying the effort to a limited number of foods, those of the greatest importance to the Armed Forces. In my mind, that does provide for an acceleration of this program.

Representative PRICE. It is an acceleration based on the progress made in the last few months after we had almost a stoppage of the program.

General LOPER. The stoppage of the program I don't think has ever happened. I have followed this reasonably close, too. What was stopped very definitely was the program for providing a pilot plant to feed some 30,000 troops. This was, as you well know, suspended last spring, a year ago almost, and then a decision was made later on in the fall to cancel it out completely.

So far as the basic research effort has gone, I am not aware that there has been any stoppage or any letup of that since it started 5 years ago.

Representative PRICE. There is some definite change in the level of support in fiscal year 1961 and also the remainder of fiscal 1960. Certainly those figures are not the same as the suggested level of support.

General Loper. This is quite true. While I am not closely associated with the budgeting part of this program or what the previously planned levels were or will be, it is my understanding that much of this reduction from the program as planned back a year ago, let us say, has been due to a decision to concentrate the reserve on a few items, and to defer the feeding programs, the initiation of construction of a pilot plant, and a number of other things which were a part of the program and presumably still will remain.

Representative PRICE. General, could you categorically state that the figure of $1,080,000 will be available for fiscal 1961?

General LOPER. No, I can't categorically state that because there is no appropriation act for fiscal year 1961. There is no money available for 1961 at the present time. So until the Congress passes an act and the money is allocated to the Department of Defense——

Representative PRICE. Is it presently in the budget request?

General LOPER. It is in the budget request and the Quartermaster General and the Army General Staff, as represented here this morning, have approved these figures. But no one can guarantee that they will be there at the time the final apportionments are made for the 1961 budget.

Representative PRICE. Can the Army use the money presently allocated to AEC for the construction of the Stockton cobalt 60 facility for their new research facility?

General LOPER. This, I believe, can be done. This money belonged to the Department of Defense. It was allocated by the Director of Defense Research and Engineering from his emergency fund. He has approved the use of it by the Army.

Representative PRICE. The allocation to the Army for the new research facility has been approved?

General LOPER. Has been approved by him. It has one more hurdle to pass. It must be approved by the Comptroller of the Department of Defense and the Secretary of Defense, and then recovered from the Atomic Energy Commission. As of this morning I had no information as to whether this had been done.

Representative PRICE. Ordinarily the Comptroller would not turn down an allocation of that sort when it has gone to this high level of approval.

General LOPER. No, he would not.

Representative VAN ZANDT. General, probably this question has to be answered by somebody from the Quartermaster General. What is the status of the project that involved the Mennonites at the Fitzsimmons General Hospital in Denver?

General LOPER. I am not familiar with that.

Representative PRICE. Is there anyone here that is familiar with that?

Mr. MORSE. That program is no longer underway.

Representative PRICE. Is there any information available on the result of the test?

Representative VAN ZANDT. I think the committee should be furnished with an evaluation of the program.

Mr. MORSE. It is being continually followed up. May I suggest that Dr. Youmans this afternoon could specifically reply to that question? He represents the Surgeon General.

Representative VAN ZANDT. Has the Army program at Camp Lee been discontinued?

General LOPER. Again I will have to refer you to the Army people. I am not familiar with the details of these programs.

General ELY. I didn't hear the question.

Representative VAN ZANDT. Has the Army program at Camp Lee, Va., involving some 300 officers and men, been discontinued?

General ELY. It involved 60 men, and it has been discontinued, I have been informed.

Representative VAN ZANDT. May we have an evaluation of the program also?

Representative PRICE. If the gentleman will yield, I think somewhere in the official records of the committee we should have some sort of evaluation of the result of this test at Fitzsimmons General Hospital. We have had reference to it several times in the testimony to the effect that there were no ill effects felt by any of the people involved in the test, but I don't think we have ever had an official report on the result.

Representative VAN ZANDT. Mr. Chairman, I think the records of the committee should show the amount of food consumed by the Mennonites in the project, and also the amount of food consumed by the officers and men at Camp Lee, and any ill effects that the persons concerned in these two programs may have developed.

Representative PRICE. Could the Department supply us with information on the results of these two tests?

General LOPER. Yes, sir. I will obtain this and get it to you. As you well understand, the feeding programs have been discontinued, as has been testified. What you would like to have is an evaluation of these feeding programs.

Representative PRICE. Would Mr. Morse like to make a comment?

Mr. MORSE. If it meets with your approval, I would suggest that I ask the Surgeon General to submit the facts for the record in a letter.

Representative PRICE. I think it should be. I don't think we have ever had an official report on this program. Do you think it would be possible to get any material over this afternoon?

Mr. MORSE. I will try to get something for you in writing this afternoon if I can. If not, it will be submitted for the record.

Representative PRICE. Thank you. (See app. 2-6, p. 771.)

Representative VAN ZANDT. What activity has been demonstrated by the Surgeon General of the Public Health Service as far as this program is concerned?

General LOPER. Again I would have to refer you to the people who have been in direct conferences with him. Is there anyone here that can testify as to what contacts have been made and the views of the Surgeon General of the Public Health Service?

Representative VAN ZANDT. I asked General Loper the question regarding the activity of the Surgeon General of the Public Health Service as far as this program is concerned.

Dr. SCHWAB. The Food and Drug Administration is a member of the Interdepartmental Committee.

Representative VAN ZANDT. When did they become a part of the activity?

Dr. SCHWAB. 1954 or 1955, I believe.

Representative VAN ZANDT. Have they actively sat in on all of your conferences and participated in any findings?

Dr. SCHWAB. I would not say all of them, but they have participated in our program and have approved our protocols.

Representative VAN ZANDT. Thank you.

Representative PRICE. Thank you very much, General Loper. I wonder if the committee could have the presence of Mr. Morse this afternoon, or someone from the Quartermaster General's office and the Army R. & D. section?

Mr. MORSE. Yes, sir.

Representative PRICE. In the event that something might come up during the hearing as in the case of the previous witness, we would have to refer back to the various departments.

Mr. MORSE. We will all be here at 2 o'clock.

Representative PRICE. The next witness will be Commissioner Floberg of the AEC.

How long is your statement, Mr. Floberg?

Mr. FLOBERG. This statement, Mr. Chairman, is 14 double-spaced pages.

Representative PRICE. I think we will probably have to take a recess now and come back at 2 o'clock. Would that be inconvenient to you?

Mr. FLOBERG. No; that would be convenient for me. I suspect it will take 25 minutes to read this into the record.

Representative PRICE. Then the committee will stand in recess until 2 o'clock this afternoon.

(General Loper's prepared statement follows:)

STATEMENT BY HON. HERBERT B. LOPER, ASSISTANT TO THE SECRETARY OF DEFENSE (ATOMIC ENERGY)

FOOD IRRADIATION

Mr. Chairman and members of the committee, I have been requested to testify before you on the Department of Defense interest in food irradiation.

In conjunction with its responsibility for single managership for subsistence for the Department of Defense, the Department of the Army has been conducting research in the field of food processing. This effort has included the field of preservation of foods by irradiation. Witnesses from the Department of the Army have given you the status of the program and background data, so I will confine my remarks to a brief statement of the interest of the Department of Defense in the food irradiation process.

The Department of Defense is greatly interested in food processing procedures which offer promise of improving the quality of foods for the Armed Forces. Improved quality and variety are particularly important under conditions where the Armed Forces may be subjected to abnormal hazards and discomforts for long periods of time. Food irradiation appears to offer possible means of substantial improvement.

The aim of the 5-year program initiated by the Quartermaster General in 1953 was to more adequately satisfy the continuing requirement of the Department of Defense for an adequate and wholesome supply of food for its fighting forces. This requirement extends itself into several areas. Among these are: light weight, palatability, wholesomeness, storage without refrigeration, minimal storage space, preparation time, preparation equipment, and trained personnel for preparation. Since the current operational rations fall short in one or more of the above, the field of irradiation of food was and is being examined as a possible means of improving logistics of troop subsistence.

The present standard feeding situation in the services when stable and static conditions exist, and manpower, cooking, and refrigeration equipment are available, may be vastly improved by reducing one or more of the above areas.

Small, mobile, dispersed units of the Army and those operating in forward areas require operational rations in a variety with considerable improvement in taste and acceptability over those currently available. Manpower, money, and equipment can be saved by a capability to supply fresh-like food requiring no refrigeration.

The development of the long-range atomic-powered submarine possibly represents the best example where improvements in subsistence are vitally needed for the Navy. However, vast savings may be possible in all ships if partially prepared, easily packaged, wholesome and palatable rations can be provided.

The problem of providing food for the crew members of long-range, high-altitude aircraft of the Air Force is apparent. This problem would be considerably increased in space flight.

The Department of Defense is particularly interested in radiation processing as a means of improving subsistence for the fighting forces for the above and other vital situations. However, it is expected that if the Army's research program contributes to improving preservation and packaging procedures for food, the public at large will benefit as it always has from research and development efforts of the military services in areas that can be applied to civilian use.

(Thereupon at 11:50 a.m., a recess was taken until 2 p.m., the same day.)

AFTERNOON SESSION

Representative PRICE. The committee will be in order.

Our first witness this afternoon will be Mr. Floberg, member of the Atomic Energy Commission.

Mr. Floberg, I am sorry we were interrupted at the noon hour when you were about to give your statement. But we regard you so highly as a witness we wanted to be sure we had adequate time to question you after your statement.

STATEMENT OF JOHN F. FLOBERG, COMMISSIONER, ACCOMPANIED BY DR. PAUL C. AEBERSOLD, DIRECTOR, OFFICE OF ISOTOPES DEVELOPMENT, ATOMIC ENERGY COMMISSION

Mr. FLOBERG. I have a prepared statement which I would like to read for the committee.

Since our appearance before this committee during the hearings on radiation preservation of food in January, the Commission has approved a radiation processed foods program. The committee was notified of the establishment of this program on March 9, 1960. (See p. 742.)

The Commission's program will be directed to the study of low-dose radiation processing of perishable foods to extend their shelf life, using radiation doses ranging from a few hundred thousand r.a.d. up to 1 million r.a.d. Initial emphasis will be on fish and fruit.

Low-dose radiation processing promises to be the most immediately useful civilian application of ionizing radiation for food processing purposes.

It would contribute to civilian food distribution objectives of making food available in as near fresh condition as possible, minimizing processing effects in quality, and balancing supply with demand.

It would also have important economic value in the United States, as for example, by making it possible to distribute near-fresh perishable foods in distant markets which cannot now be reached because of too rapid food spoilage.

The AEC low-dose radiation processing program, as well as the Army's high-dose radiation sterilization program, also give direct support to the President's atoms-for-peace program—other countries have great interest in the possibility of using radiation processing to improve their food distribution and increase the variety and quality of food products available. Many countries are conducting research and development in this area.

In low-dose processing we are concerned with partially destroying and inhibiting the action of microorganisms causing rapid spoilage of foods. With high-dose processing, such as the Army is studying, the objective is to sterilize the food by killing virtually 100 percent of the spoilage organisms.

Let me use milk as an analogy to illustrate this further. We all are aware that by a mild heat treatment we obtain pasteurized milk. This must be kept refrigerated and will remain unspoiled for several days. Pasteurization delays spoilage. By intense heat treatment we obtain sterilized milk which is canned. This can be stored indefinitely without refrigeration. For our purpose here low-dose radiation processing could be compared to pasteurization and high-dose radiation sterilization to heat sterilization.

Another characteristic of low-dose radiation processing is that to extend the shelf life of food this way requires only about one-tenth as much radiation as is necessary for radiation sterilization.

In other words, a facility designed for high-dose radiation sterilization can process 10 times as much low-dose-treated foods as sterilized foods.

Our preliminary investigations already give us confidence in the ultimate success of low-dose radiation processing to extend shelf life.

Such also is the consensus of a number of experts on radiation processing of foods whom we have consulted.

This belief is further supported by preliminary research in the United States, primarily by the U.S. Army Quartermaster Corps and in other countries.

Further, such low-dose processing is said generally to entail negligible or no changes in the foods taste, color, or odor.

With this background, I should like now to outline the Commission's program in detail. The objectives of the AEC program are to:

Concentrate on a relatively few low-dose, radiation-processed foods, so as to achieve success sooner than would be possible if a multitude of food products were studied concurrently.

Establish wholesomeness and safety of selected low-dose, radiation-processed foods.

Proceed as rapidly as possible, consistent with the state of the art and requirements for sound scientific research.

The Commission will conduct the basic research necessary for advancing low-dose radiation processing of foods to the point of technical and practical feasibility. Emphasis will be placed on basic studies in food chemistry, microbiology, wholesomeness testing, preirradiation and postirradiation factors of shelf life extension and radiation process technology.

However, such additional work as product and market development to establish low-dose radiation processing as a routine commercial food-processing method would be the responsibility of private industry.

The Commission has approved expenditure for this program of $115,000 for fiscal year 1960 and $500,000 for fiscal year 1961. We currently estimate the program will cost $5 million for 5 years.

The Commission is convinced that time will be gained and sounder results obtained by first carefully formulating the specific details of a sound, integrated scientific program.

Accordingly, we have initiated comprehensive studies to design a low-dose radiation research program for specific foods promising substantial technical and economic significance in food production, processing, distribution, marketing or consumption. It is expected this will require 6 to 8 months for completion.

As stated earlier, we are immediately directing our attention to fish and fruit. The committee has previously been provided with copies of a report prepared by the Massachusetts Institute of Technology under contract to the AEC which evaluated the technical, economic, and practical feasibility of radiation preservation of fish. The report—

> concludes that low-dose radiation processing of certain selected marine products can provide important advantages for the producer, processor, distributor, as well as the consumer, and
>
> recommends that a comprehensive program be initiated for the development of low-dose radiation processing of marine products.

Preliminary experimental work, primarily by the Army Quartermaster Corps, on marine products has revealed several products meriting development.

These include flounder, ocean perch, halibut, shrimp and crab. For example, cooked crab normally can be kept only about 7 days under refrigeration. Experiments indicate that radiation-processed cooked crab treated with a low dose of 400,000 r.a.d. can be kept approximately 30 days under normal refrigeration.

In texture and flavor the product is virtually indistinguishable from freshly cooked crab. Thus, through radiation processing, crab and other marine products can be introduced in as near as fresh condition as possible into areas which now can get only frozen or canned fish. Such fish can also be kept longer by the consumer.

Accordingly, a second phase of work has been initiated with MIT in concert with the Bureau of Fisheries to develop a specific plan of research and development, including estimated costs leading to technical demonstration of low-dose radiation processing of fish.

We expect completion of this work by midsummer and initiation of experimental studies promptly thereafter.

Preliminary experimental work, much of which was sponsored by the Army Quartermaster Corps, indicates that peaches, citrus fruits, grapes and strawberries are worthy of further investigation.

One objective of radiation processing of fruits is to retard spoilage due to fungi. It appears that this can be accomplished with low doses on the order of 250,000 r. a. d. and increases the marketable life significantly.

West coast strawberries, for example, could be marketed in the East for an additional 2 to 3 days as compared to nonradiation processed berries. Even so short a shelf life extension as this could have significant market impact.

Another possible application of radiation processing to fruits is to slow down the ripening process. Some fruits such as peaches often are picked while fairly green so that they will not be overripe by the time they reach the market.

Preliminary experimental work indicates that low-dose radiation processed fruits take longer to ripen. In this case the fruit could be allowed to ripen more before being picked, with consequent enhancement of flavor and quality, and will not be overripe by the time it reached the market.

Accordingly, we have begun an analysis of the technical and economic feasibility of low-dose radiation processing of fruits under contract with Stanford Research Institute. The Department of Agriculture is working closely on this project with the AEC.

We expect to complete this analysis and to design an experimental program within the next few months. This will permit initiation of actual research on radiation processing of fruits during the early part of the next fiscal year.

Since our work during the next 6 to 8 months will be the development of detailed research programs on low-dose radiation processing of fish and fruit, it is not possible to be too specific on actual plans at this time. However, we can outline for the Commission the general pattern in which we expect to proceed.

We must first select the specific fish and fruits upon which our studies will concentrate. The selection process will involve cursory testing of many more varieties of fish and fruits than we plan to study in detail.

We would then concentrate on representative varieties which appear to benefit materially from low-dose radiation processing and which have marketing potential. We would determine how the selected fish and fruit are affected by various amounts of radiation with emphasis being placed on doing the processing in a manner that would be practical for commercial application. We would determine how much the usable life of the products is extended and ascertain the effects on taste, texture, appearance, vitamin content, et cetera.

One objective that would be kept in mind throughout this testing program is the determination of the practicable technical and commercial limitations within which to conduct our more extensive re-

search work. By so proceeding we can have greater assurance that the results from subsequent long-term and costly wholesomeness experiments will be truly meaningful for practical commercial application.

Concurrently with the above studies, we will initiate work on developing guidelines for a research program to establish wholesomeness and safety of low-dose radiation processed foods.

Sufficient research has not yet been carried out on alteration of dietary constituents of foods, that is, proteins, vitamins, et cetera, treated with low radiation doses.

We will want to conduct detailed food chemistry studies to establish that low-dose radiation processing of foods does not alter the nutritional value of such foods to the extent of compromising their ultimate unrestricted clearance for human consumption.

We have established close liaison and are currently working with the Food and Drug Administration to design a comprehensive test program on the nutritional and toxicological safety of low-dose radiation processed food, including the experimental protocol for animal feeding experiments.

I am certain that the committee recognizes and appreciates the high degree of competence which has been built up in the atomic energy program on the effects of very low doses of radiation on the biological brought to bear directly on evaluation of the toxicological safety of and physiological behavior of animals. This competence can be brought to bear directly on evaluation of the toxicological safety of radiation processed foods under the Commission program.

It should be noted that additional data to that obtained in the wholesomeness and safety program of the Department of the Army on high-dose radiation sterilization of foods may be needed to support clearance of similar classes of foods processed with low doses of radiation. We expect to clarify this matter as our work progresses with the Food and Drug Administration.

We would not expect to initiate a comprehensive animal feeding program to test the nutritional and toxicological safety of low-dose processed foods until we have established the preirradiation and postirradiation factors influencing product quality and optimum periods of shelf life extension for the specific foods selected for study in the low-dose program.

Therefore, the comprehensive animal feeding tests under wholesomeness and safety aspects of the Commission's low-dose radiation processed foods program cannot be started until the latter part of the next fiscal year.

Important to the initiation and full development of the Commission's radiation processed foods program are adequate irradiation facilities. The type and number of such facilities will become more clearly established as the initial activities now underway are further along.

Under its currently approved program, the Commission will, however, design and construct two portable laboratory research irradiators. These irradiators will employ 10,000–20,000 curies of cobalt 60. The research irradiators will be used to carry out basic studies on the effect of low-dose radiation processing on the nutrition of foods as well as to investigate the origin and control of factors affecting the food's odor, taste, color, and texture.

It may be that additional laboratory research irradiators will be required to properly support the fully implemented research activities of the low-dose program. If these needs develop, the Commission will provide for them.

As full details of the research program on low-dose radiation processed foods are evolved, the need for more specialized types of irradiation facilities will be established as well as specific design characteristics.

It may be that mobile irradiators using 50,000 to 150,000 curies of cobalt 60 will be required to test process selected foods at places where they are harvested and packaged for transportation to markets.

This requirement would stem from a need to experimentally establish radiation process conditions preparatory to animal feeding studies as mentioned earlier. The product throughput of irradiators of the mobile type would also be sufficient to provide required quantities of low-dose radiation processed foods for the animal feeding studies.

As the committee knows, the Department of the Army has announced its revised program on radiation sterilization of foods which includes plans for construction of a radiation research center. The center will include a 1-million-curie cobalt 60 irradiator, a linear accelerator and a food preparation facility.

The cobalt 60 irradiator will be of a highly flexible design permitting its use in both high-dose and low-dose radiation processed foods research.

The Department of the Army has indicated its willingness to make the radiation center available for conduct of studies under the Commission's low-dose program. We shall certainly take advantage of the Army's invitation to the extent this is practical, both from the availability of the facility without interferences with the Army research activities and as the facility meets our specific program needs.

The AEC has authorization and is currently proceeding with work to construct a High Intensity Radiation Development Laboratory. This facility, to be located at the Brookhaven National Laboratory, will be highly flexible and capable of safely handling 1 million curies of cobalt 60.

The plan for the building includes small research laboratories, as well as two high-intensity radiation source handling cells. The facility will be available for use in midsummer 1962.

The program with this new facility will include experimental studies of factors affecting the design of large irradiators, such as radiation dose delivered at different points within a target, source dimensions, target dimensions, optimum source and cladding dimensions, optimum design of high efficiency irradiators, heat generation and dissipation in high level sources, and radiation damage to source materials.

The High Intensity Radiation Development Laboratory is not intended as a food research center, but it will contain many of the elements required of an integrated research and development center for low-dose radiation processing of foods. It may be as the AEC's radiation processed food program becomes more fully developed a requirement for such a research center will be established or some modification therefore, that is, a marine products radiation research center or possibly an agricultural products radiation research center.

If a need for an integrated research center becomes apparent, the Commission would consider its establishment at the Brookhaven National Laboratory and would provide for the additional facilities necessary such as food preparation and research laboratory space. In the meantime we envision partial use of the High Intensity Radiation Development Laboratory to carry out experimental work on radiation process development for foods.

In summary, with regard to radiation facilities, the Commission believes that it would be premature to seek authorization for its construction of a radiation research center for its low-dose radiation processing of foods program. It is by no means clear at this time that such a center would be the type of facility to best support the program.

Smaller radiation facilities placed near food production centers, and perhaps of a mobile nature, may prove to be the type of equipment that is needed. The detailed programing of the next 6 to 8 months should serve to clarify this need.

Meanwhile, the Army's decision to construct its radiation research center which will be available to the Commission's program, and the Brookhaven facility now under construction should provide for such radiation center needs as can now be foreseen.

In developing its program, the Commission gave full consideration to the report of the Interdepartmental Committee on Radiation Preservation of Food, "A National Civilian Radiation Processed Foods Program."

We believe the AEC program is fully consistent with the objectives and program elements set forth in that report. Although we do not find it feasible or wise to achieve the budgetary levels set forth in the report so quickly, our projected total expenditures over the next 5 years closely approximates the level recommended in the Interdepartmental Committee report.

The Commission intends to administer its radiation processed foods program in an aggressive and productive manner. We plan to maintain full and active liaison with other interested Government agencies as well as to keep commercial food processing firms fully informed on our progress under the program.

Further, in view of the international interest in low-dose radiation processing of foods, we are currently establishing procedures for positive exchange of information with other countries carrying out research in this field.

The Commission and the Department of the Army have established close working relations for coordinating their respective radiation processing foods programs. We are confident that positive benefit can accrue from one program to the other and that the radiation processing foods activities of the Army and the AEC are complementary and not duplicative.

I should like to conclude my testimony by stating that the Commission intends to pursue its radiation processed foods program as vigorously and rapidly as scientific prudence indicates.

On the other hand, food is a complex biological material so that methods for processing it with radiation as well as establishing its safety after radiation treatment is a formidable task. Thus, it is proper to end with an expression of confidence, but with a word of caution that we should not expect spectacular results in a short period of time.

That concludes my prepared statement, Mr. Chairman.

Representative PRICE. Thank you very much, Mr. Floberg. On page 4, where you refer to the allocation of funds for fiscal years 1960 and 1961, are they being taken from any other Commission projects to be allocated for this program?

Mr. FLOBERG. The 1960 funds are found in the Commission's overall budget because this is the budget under which we are currently operating. This money must be obtained from under runs on some other project or from some reprograming of some sort or another. As you know, the 1961 budget is currently before the Congress and our hearings start before the Appropriations Committee Tuesday after Easter, I am told today. So this $500,000 for fiscal 1961 will have to be obtained by selection from some other budgeted item in the budget. There is no question about that. Of course, the budget does go through certain metamorphoses prior to the time it is presented to the Congress as well as after it is presented to the Congress.

Representative PRICE. What type of funds will it come out of, isotope development?

Mr. FLOBERG. I don't know, Mr. Price. Maybe there is somebody here who can tell me precisely what subtraction has taken place.

Representative PRICE. Is the $5 million figure for 5 years which is mentioned in paragraph 10 of page 4 of your statement an AEC figure as separate from the Army?

Mr. FLOBERG. Yes, sir. This, your understand, is a long-range estimate and it could turn out to be high or too low. When I start estimating budgets 5 years ahead of time, I am pretty bold.

Representative PRICE. Looking at the chart that you have there, Mr. Floberg, which the Joint Committee staff asked the Commission to prepare, and looking at the AEC program as compared with the panel recommendation in the Interdepartmental Committee, which I understand was headed up by Dr. Aebersold, there seems to be quite a difference in the recommendations of that panel as against the planned activity of the AEC itself. Would you care to comment on the reason why the AEC did not believe it feasible to go fully with the recommendations of this Committee?

Mr. FLOBERG. We were well aware of the recommendations of the panel when we established our program. It was our feeling that the ad hoc panel's recommendations were stepping off the high board a little too quickly, and that we coud not employ the funds recommended to full advantage at the rate at which they were recommended to be employed. We thought that the rate that we settled on was about as quickly as we could get full value for the dollars in question. The total dollars, as you will notice, over the full period are not markedly different. If you give us a reasonable margin of error for a 5-year estimate, that is. It certainly is true that in the first 2 years there is a difference. This is a matter of judgment as to how quickly one can plunge into a new program. I would like to call your attention, Mr. Price, to the fact that we are in 1960 now and the budgeted figure was at zero up to this time. We are trying to start something from a standing start, and trying to get our maximum dollar value. Maybe our figures are wrong, but this is what we thought was reasonable for getting maximum productivity.

LOW DOSE RADIATION PROCESSED FOODS PROGRAM

	A E C*		AD HOC PANEL**	
	FY 1960	FY 1961	FY 1960	FY 1961
START-UP ACTIVITIES	75,000	100,000	200,000	—
RESEARCH IRRADIATORS (KILOCURIE)	40,000 (1)	40,000 (1)	200,000 (4)	—
MOBILE IRRADIATORS	—	—	—	400,000 (2)
FOOD CHEMISTRY MICROBIOLOGY SUPPLEMENTARY WHOLESOMENESS	—	200,000	—	180,000
FOOD TECHNOLOGY	—	160,000	—	340,000
TOTAL	115,000	500,000	400,000	920,000

*ESTIMATED EXPENDITURE OF $5,000,000 OVER 5 YEARS.
**ESTIMATED EXPENDITURE OF $6,000,000 OVER 5 YEARS.

Representative PRICE. The chart shows that the estimated expenditure over a 5-year period by the Commisison is $5 million, by the ad hoc panel will be $6 million; yet in the first 2 years of the 5-year program the ad hoc figures ran in one instance in the fiscale year 1960 better than 2 to 1, and in the fiscal year 1961 almost 2 to 1. That means somewhere along the line we are going to have some sort of gap that we will have to carefull watch.

Mr. FLOBERG. The difference is between $1.3 million for 2 years and $600,000 for 2 years. In other words, they estimate twice the expenditures in the first 2 years that we have estimated. A major part of this, as you can see, is in the timing of the mobile irradiators. It may well be that we can move the date for these up by a year but we are certainly not ready to do it now. We are talking about the 1961 budget.

Representative PRICE. Is the timing on the mobile irradiators due to a very careful analysis and study to the effect that the Commission does not think it is possible to get into this within the next 2 years?

Mr. FLOBERG. I would not say it was impossible, Mr. Price. I do think we are approaching the commencement of fiscal year 1961, now, it is a real question as to whether we could get those mobile irradiators squeezed into the 1961 budget. Conceivably we could, but I don't think it is unreasonable to say that they can just as well come out of the 1962 budget.

Representative PRICE. That is one of the tools.

Mr. FLOBERG. It is one of the tools.

Representative PRICE. In order to do a good research job you have to have certain tools.

Mr. FLOBERG. That is right. But we are still trying to figure out how to make this tool.

Representative PRICE. It seems to me in setting up the basic program you would place some emphasis on obtaining the tools; otherwise you run the danger of not meeting the schedule after the third year.

Mr. FLOBERG. That is certainly true. The point is that this is not an off-the-shelf tool. This is a tool we have to invent. The question of how quickly we will be prepared to design it and procure it is a pretty tough question.

Representative PRICE. I wonder if Dr. Aebersold can give any expression of whether or not he believes this mobile irradiator could possibly be in the picture within the next fiscal year or so, or why they set such store on the funds for fiscal 1961 for the mobile irradiator.

Dr. AEBERSOLD. There are other members of the ad hoc working panel of the Interdepartmental Committee here who will testify later, but it seemed to us that one of the problems in the field of irradiating fresh food is to have the irradiators closer to the sources of food production. For example, berries are commercially shipped either in California or some southern place like Louisiana. Both provide large quantities of berries for the market. In the case of fish, the major centers of fish catching are around Boston and Seattle. Our idea was that we might have irradiators that could be moved from one part of the country to the other to study the items as they are harvested and in the market distribution pattern. You must realize that we have not designed any irradiators other than the very-high-intensity facility (HI–FI) that we were designing for the Army's pilot plant at Stockton. That was our only responsibility up until October 22, when the Army made its announcement that they would defer the Stockton facility. We had not been studying other irradiation facilities prior to that time.

We have since begun to look into the design of research irradiators and mobile irradiators. We have assigned to Brookhaven National Laboratory the role of major irradiator designer for the Commission. BNL is now making conceptual designs of several irradiators. I have some charts here to show these if it would help the committee.

Representative PRICE. Do you have any other outside consultants?

Dr. AEBERSOLD. Yes, sir. We have a number of companies that have given us ideas on the design of irradiators. If you wish names I could supply them for the record.

Representative PRICE. How about mobile irradiators?

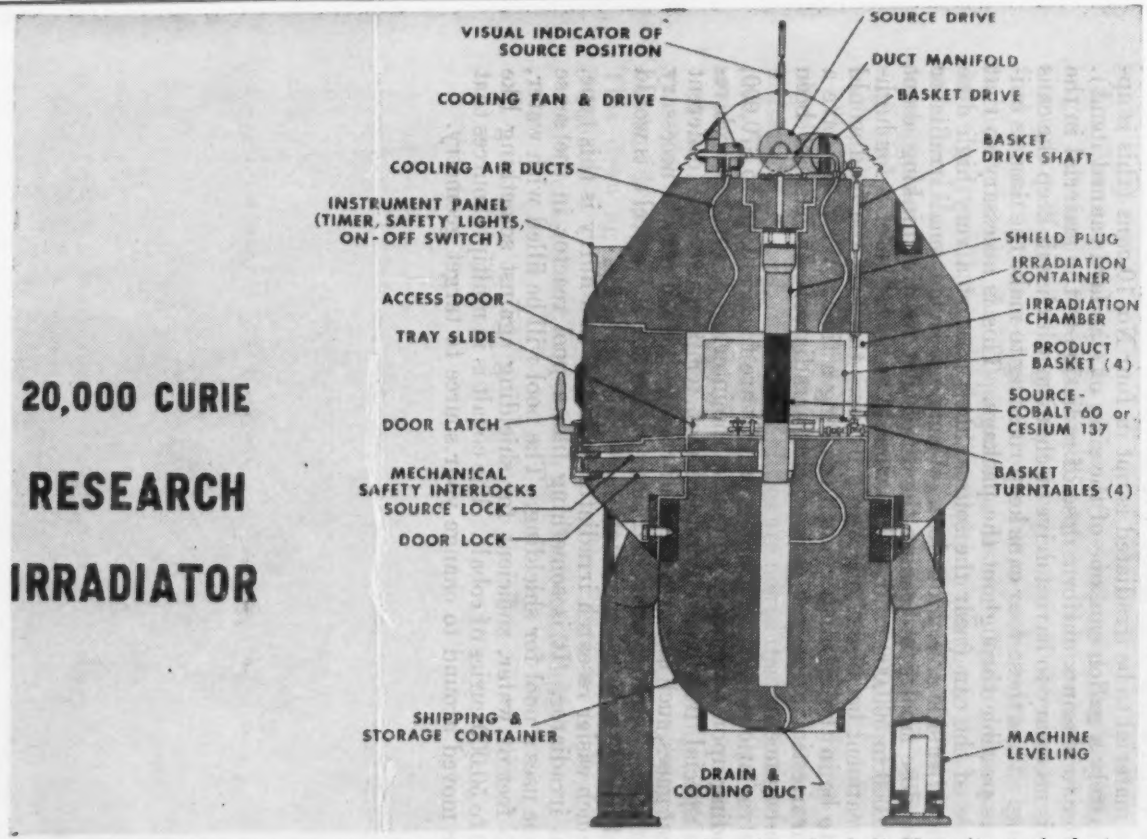
Dr. AEBERSOLD. I believe Curtiss-Wright Co. has one in conceptual design. They have not done detailed work on it, sir. It is just a conceptual design at the present moment.

Representative PRICE. Do you have any evidence of work at any place, either the Commission Laboratories or outside contractors, that indicates that they would be available within the next 2 years?

Dr. AEBERSOLD. No, sir. We are just now doing the preliminary design studies. I have some charts that show the difference between a research irradiator, a mobile irradiator, and a radiation facility. I think it would be helpful to see the difference.

Representative PRICE. I think it would.

(AEC chart 2 with descriptive data follows:)



Research irradiators generally employ ten to twenty thousand curies of cobalt 60 or its equivalent. They permit studies under closely controlled environmental conditions on chemical changes in foods as the result of irradiation. Such irradiators usually are transportable in that they can be disassembled and moved to a different location. Although they are quite flexible in terms of the environmental conditions such as temperature and humidity which are possible, their production capacity is very limited and the radiation source itself usaually is of fixed shape.

Dr. AEBERSOLD. This (AEC chart 2) is a conceptual drawing of a research irradiator, which would use about 20,000 curies of cobalt 60 as a central rod. It would be above ground in a laboratory. The shielding would be lead so it would be quite compact. Conceivably it would be shipped from place to place. It is not on wheels, and although it would weigh a few tons, it could be moved.

The material to be irradiated is put in four No. 10 cans (this is approximately a gallon can, one of the sizes of standard canned items). In order to obtain a uniform dose of radiation to the material in the can it is necessary to have a drive mechanism which will keep the cans rotating. Thus these four cans keep rotating to make the dose as uniform as possible throughout the package. This is necessary so that one side of the can (near the source) does not get a very high dose and the other side a very low dose. We can use such a small irradiator for low-dose treatment because the doses that we are thinking about are 250,000 to 500,000 r.a.d. This would not be very useful for high-dose treatment because if one wants 10 times the dose, the food would have to be in the irradiator much too long a time. We don't have a real firm estimate on the cost of this irradiator. It has not been design-engineered.

The variations in cost estimates on this are from $40,000 to $70,000, depending upon how fancy you make the interior. Some research requires special irradiation conditions of temperature and different ambient gases, such as oxygen and nitrogen. Also, it may be necessary to control the humidity and conditions of that sort. We feel this would be useful for research irradiation.

A much easier research irradiator to install in a hurry is this type, a pool irradiator. It is something like a pool reactor in the sense that one uses a pool for shielding. The pool will be filled with water, say 15 feet of water, sufficient for shielding against something like 20,000 to 50,000 curies of cobalt. The cobalt is in multiple sources that can be moved around to change your source to target geometry.

The packages to be irradiated have to be immersed and thus sealed against the water pressure. This does restrict the flexibility of the ambient conditions under which you irradiate the food. We believe this type of facility could be readily installed at a number of places as a research facility for around $25,000 to $50,000 each.

Representative PRICE. Don't they have something like that at Argonne right now?

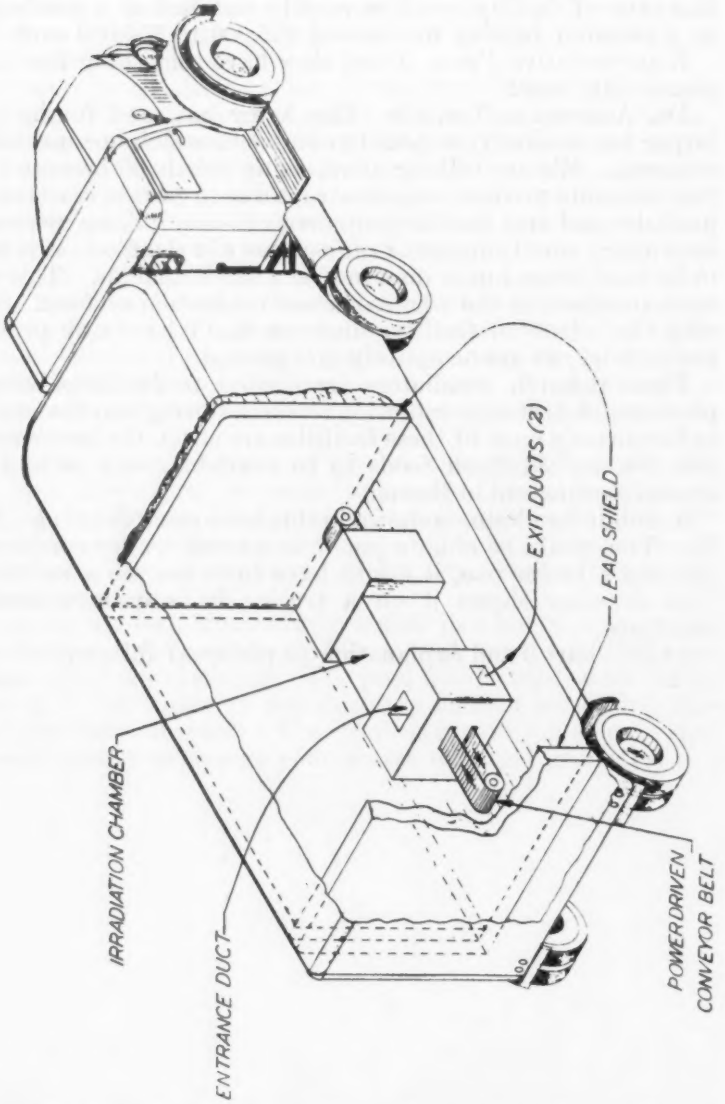
Dr. AEBERSOLD. Yes, sir. The Army has used for its program a larger but similar type pool irradiator in which one uses reactor fuel elements. We are talking about using cobalt 60 because the reactor fuel elements produce some neutrons due to certain reactions by alpha particles and also due to spontaneous fission. These neutrons can induce a very small amount of radioactivity in the food. It is not enough to be hazardous, but it does induce a small amount. This may cause some problems in the wholesomeness evaluation of food. We believe with the cobalt 60 facility, since we won't have any production of radiactivity, we are on entirely safe ground.

These research irradiators are similar to facilities being used in physics and chemistry radiation research throughout the country. But unfortunately most of these facilities are not in the locations where we find the desired fresh foods to be available, such as in California, around Seattle, and in Boston.

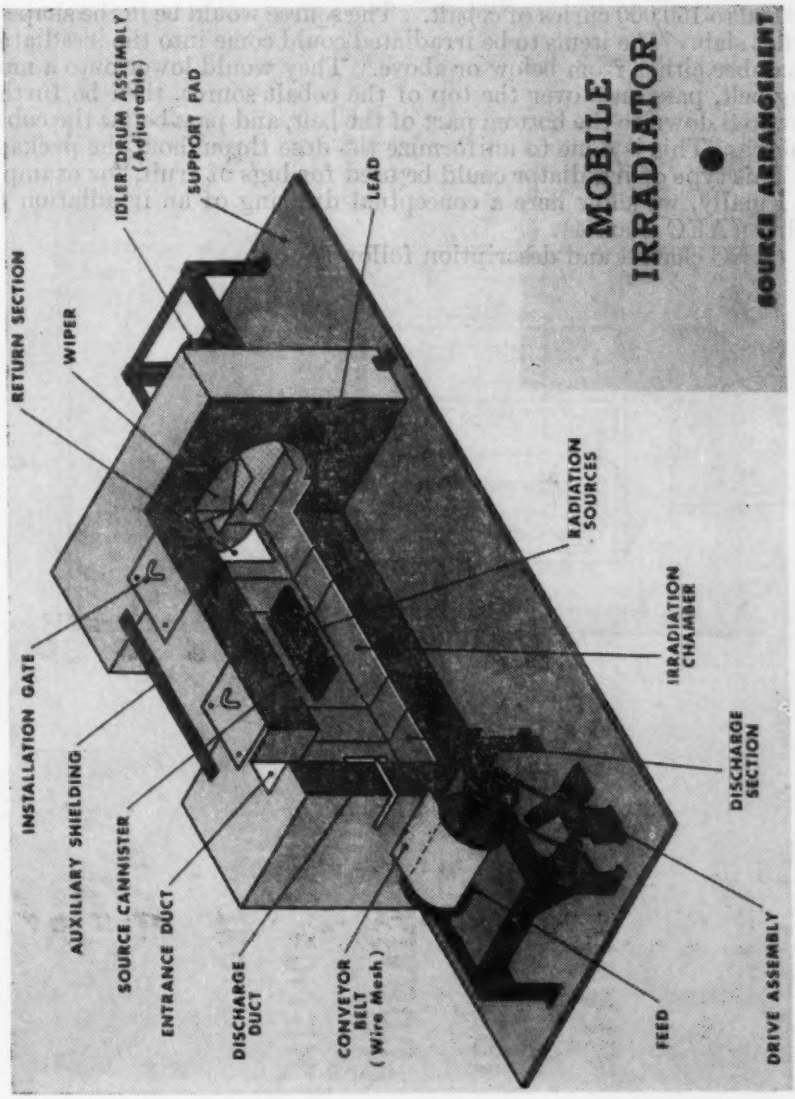
A mobile irradiator is shown in this conceptual drawing (AEC chart 3). You would be able to put it in a truck-trailer combination. If one had a larger one, it might have to be put on a railroad flatcar. This drawing shows it on a truck. It is quite a small mobile irradiator.

(AEC chart 3 and explanation (2 pictures) follow:)

MOBILE IRRADIATOR



Mobile irradiators employ fifty thousand to one hundred fifty thousand curies of cobalt 60 or its equivalent. They are mounted on tractor trailers or railroad flatcars. In this way, food can be irradiated at the site where it is harvested or processed. Such irradiators also can be moved to different parts of the country during the year and so be utilized in studies of a variety of food products. Mobile irradiators are suitable for studying process variables related to shelf life exension of foods such as total dose, dose rate, and pre-



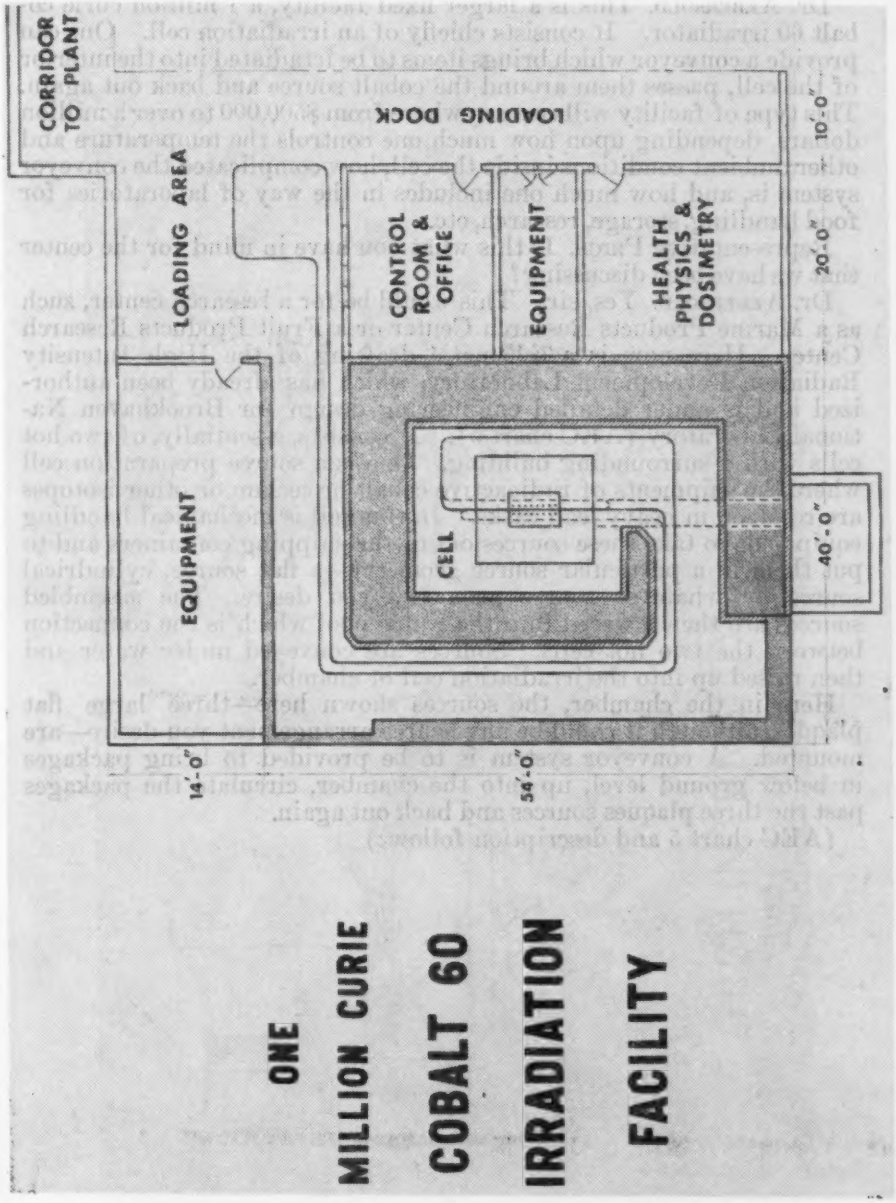
irradiation as well as postirradiation factors. They are less flexible than research irradiators with respect to environmental conditions possible, but have a much larger production capacity. They therefore can provide sufficient radiation processed foods for carrying out comprehensive animal feeding studies necessary in evaluating the wholesomeness and safety of such foods.

Dr. AEBERSOLD. These drawings were all made of Brookhaven National Laboratory, which is our center for conceptual design work on irradiators. This shows the interior of a mobile irradiator. The source strength here could be anywhere, as our testimony states, from 50,000 to 150,000 curies of cobalt. The source would be in the shape of a flat slab. The items to be irradiated could come into the irradiation chamber either from below or above. They would lower onto a moving belt, pass once over the top of the cobalt source, then be further lowered down to the bottom part of the belt, and pass below the cobalt source. This is done to uniformize the dose throughout the package.

This type of irradiator could be used for lugs of fruit, for example.

Finally, we show here a conceptual drawing of an irradiation facility (AEC chart 4).

(AEC chart 4 and description follow:)



Large fixed irradiation research facilities employ several hundred thousand to over a million curies of cobalt 60 or its equivalent. A megacurie radiation facility would be of massive concrete construction probably containing a pool for water storage of the radiation source and would be equipped with conveyor system for bringing items to be irradiated into and out of the irradiation chamber. Such facilities also usually have associated with them supporting research laboratories. The radiation source arrangement in such a radiation facility is extremely flexible so as to permit investigation of optimum source geometry from both safety and processing viewpoints. It also permits study of process engineering problems. A facility of this size principally is of interest in high-dose radiation sterilization of food. The production capacity of such a facility for low-dose processed foods would be approximately 10 times as great as for radiation sterilized foods.

UNIVERSITY OF MICHIGAN LIBRARIES

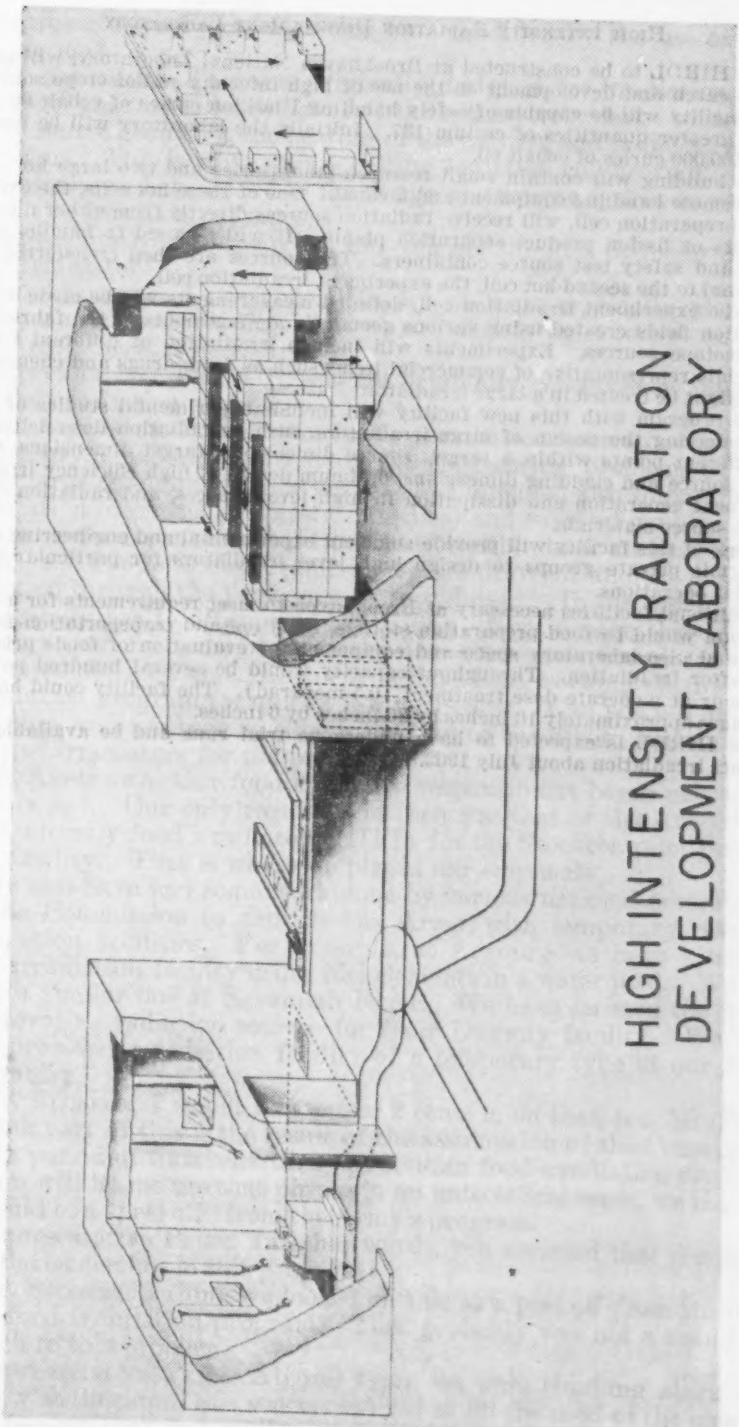
Dr. AEBERSOLD. This is a larger fixed facility, a 1 million curie cobalt 60 irradiator. It consists chiefly of an irradiation cell. One can provide a conveyor which brings items to be irradiated into the interior of the cell, passes them around the cobalt source and back out again. This type of facility will cost anywhere from $500,000 to over a million dollars, depending upon how much one controls the temperature and other ambient conditions inside the cell, how complicated the conveyor system is, and how much one includes in the way of laboratories for food handling, storage, research, etc.

Representative PRICE. Is this what you have in mind for the center that we have been discussing?

Dr. AEBERSOLD. Yes, sir. This would be for a research center, such as a Marine Products Research Center or a Fruit Products Research Center. Here now is a schematic drawing of the High Intensity Radiation Development Laboratory, which has already been authorized and is under detailed engineering design for Brookhaven National Laboratory (AEC chart 5). It consists, essentially, of two hot cells with a surrounding building. One is a source preparation cell where the shipments of radioactive cobalt or cesium or other isotopes are received in heavy lead casks. In this cell is mechanical handling equipment to take these sources out of the shipping containers and to put them in a particular source geometry—a flat source, cylindrical source or whatever source geometry you desire. The assembled sources are then lowered into the water pool which is the connection between the two hot cells. Sources are conveyed under water and then raised up into the irradiation cell or chamber.

Here in the chamber, the sources shown here—three large flat plaques, although it could be any source arrangement you desire—are mounted. A conveyor system is to be provided to bring packages in below ground level, up into the chamber, circulate the packages past the three plaques sources and back out again.

(AEC chart 5 and description follow:)


HIGH INTENSITY RADIATION
DEVELOPMENT LABORATORY

High Intensity Radiation Development Laboratory

The HIRDL to be constructed at Brookhaven National Laboratory, will serve for research and development on the use of high intensity radioisotope sources. This facility will be capable of safely handling 1 million curies of cobalt 60 and much greater quantities of cesium 137. Initially the laboratory will be loaded with 500,000 curies of cobalt 60.

The building will contain small research laboratories and two large hot cells with remote handling equipment and a canal. One of these hot cells, the experiment preparation cell, will receive radiation sources directly from either nuclear reactors or fission product separation plants. It will be used to handle, clad, weld, and safety test source containers. The sources are then transferred via the canal to the second hot cell, the experiment irradiation cell.

In the experiment irradiation cell, detailed measurements will be made of the radiation fields created using various geometric arrangements of the fabricated radioisotope sources. Experiments will include irradiation of different target materials representative of commercial items such as food, drugs and chemicals, that might be treated in a large irradiator.

The program with this new facility will include experimental studies of factors affecting the design of large irradiators, such as radiation dose delivered at different points within a target, source dimensions, target dimensions, optimum source and cladding dimensions, optimum design of high efficiency irradiators, heat generation and dissipation in high level sources, and radiation damage to source materials.

Work of this facility will provide sufficient experimental and engineering data to permit private groups to design high level irradiators for particular commercial operations.

Additional facilities necessary at Brookhaven to meet requirements for a food program would be food preparation storage, handling and transportation facilities, and also laboratory space and equipment for evaluation of foods prior to and after irradiation. Throughput capacity would be several hundred pounds per hour at moderate dose treatment (0.5 megarad). The facility could handle packages approximately 16 inches by 20 inches by 6 inches.

The HIRDL is expected to have undergone trial runs and be available for product irradiation about July 1962.

Representative PRICE. Has this been modified by the use of food irradiation?

Dr. AEBERSOLD. This was originally designed for "radiation engineering," that is, to learn how to handle these very large sources, to study source geometry, the heating of the sources, and radiation safety problems. This is what we are calling radiation engineering.

Recently we have added to the design a conveyor system so we will be able to irradiate packages.

Representative PRICE. When did you get the idea of using it as a food irradiator?

Dr. AEBERSOLD. I don't mean to say we were originally planning to use it as a food irradiator but we are modifying it so we can irradiate food there, if necessary.

Representative PRICE. It was not originally conceived or intended for the irradiation of food.

Dr. AEBERSOLD. It was principally a radiation source development laboratory, a laboratory to study the engineering problems of handling large amounts of radiation. It was intended also for studies on irradiation of chemicals, plastics, medical and surgical supplies. Of course, a food package could be made similar to a medical supply package. The total dose requirements are different and the dose distribution through the package may be different. In the case of food, one usually has to attain a much more uniform dosage through the package than for some of the other uses I have mentioned.

Representative PRICE. Doctor, you have been working on this food irradiation program for quite a few years now. Can you tell me why it is that we have been so slow in getting to the design and development of irradiators for the program?

Dr. AEBERSOLD. Our food irradiator responsibility began only about 2 years ago. Our only requirement then was that of the Army for a high intensity food irradiator (HIFI) for the Stockton pilot production facility. That is where we placed our emphasis.

We also have had some work done by various national laboratories of the Commission to provide the Army with temporary research irradiation facilities. For example, at Argonne we have a temporary irradiation facility using fuel elements in a water pool. We also have a similar one at Savannah River. We have assisted the Army in providing radiation sources for their Dugway facility. We have also provided a radiation facility of a temporary type at our MTR laboratory.

Mr. FLOBERG. I would like to toss 2 cents in on that, too, Mr. Price. I think part of this is the result of the assumption of the Commission over a period of time regarding the civilian food irradiation program. If you will let me use that phrase in an untechnical sense, we thought it would be a "peel off" from the Army's program.

Representative PRICE. In other words, you assumed that the Army had the leadership in this program?

Mr. FLOBERG. I think we looked on this as a peel off from the military food irradiation program. That probably was not a sound approach to this problem.

Representative PRICE. All the years we were thinking about this facility at Stockton, this was considered to fill the need of the irradiation facility that you might require in the program. So there is a considerable lag in the design of any other type of irradiator.

Mr. FLOBERG. I think it was not looked on sufficiently independently to give a rate of progress that probably should have been given. Most of what the Army has been doing will be relevant, I think. It is true that the distinction between the programs was not adequately realized until last fall. This is my opinion. I don't know if others agree with me.

Representative PRICE. Dr. Aebersold has been on the interdepartmental committee. I wonder if he would make a comment on the evident lag of the assumption of AEC in the civilian program due to the fact that it was assumed during these years that the Army had the leadership in the program?

Dr. AEBERSOLD. That was our assumption. We do feel that some of these temporary facilities are adequate for the Army's purposes when one can study irradiation of frozen food, when you don't necessarily have to irradiate fresh food. If the objective is complete sterilization it is possible to ship the food around a great deal more, whereas, for civilian uses we are interested in studying the extension of shelf fresh foods. This difference has not really been looked into in detail until the recent ad hoc work panel came together. We then realized that one of the problems in doing anything meaningful in this field of low dose treatment with fresh fruits and fresh fish is the problem of shipping these products back and forth across the country to the present irradiation facilities. It was the panel's recommendation, therefore, that to make this field of low dose treatment go ahead, one should look into the design of research irradiators and mobile irradiators which would be useful near where the fresh foods are produced.

Representative PRICE. Mr. Floberg, I wonder if you would comment on the following paragraph from the letter the chairman of this committee, Senator Anderson, directed to Mr. McCone on March 7 of this year, in which the chairman says this:

> The failure of our Government to adequately support the food irradiation program, I believe, is merely symtomatic of our entire atoms for peace program. The many glowing promises which were made to the world during the period 1953 to 1956 have not been fulfilled. It may still not be too late. We cannot, however, afford to waste any more time nor to make promises to our free world friends that are not being supported by our actions. The Commission today, I believe, should be in a position to go ahead with the program and endeavor to put it back into operation and further its advancement.[1]

Do you care to comment on that statement of the chairman's letter to Mr. McCone?

Mr. FLOBERG. Maybe it is presumptuous of me to comment on that, Mr. Price. Mr. McCone has already answered that letter with a letter dated March 24 which I believe is in the possession of the subcommittee. I think if I would make a comment, I would say that the last sentence of the paragraph which you read is not inconsistent with any testimony that I have given here today or with the intention of the Commission to get this program rolling and keep it rolling.

If the second sentence about glowing promises is meant to be interpreted that publicity runs away ahead of performance in the nuclear energy business, I sure agree with that. It has been characteristic of it.

Representative PRICE. Do you feel that this is an accelerated program?

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[1] See p. 741 for full letter; p. 744 for AEC reply.

Mr. FLOBERG. If you take the analysis that it is starting from zero it certainly is accelerating.

Representative PRICE. If you take it from a standstill it has accelerated.

Mr. FLOBERG. Of course, because we had a zero program up until recently. So it is obviously accelerating. If you ask me if this is a high-speed program, I would say no, and I don't think it should be.

Representative PRICE. Do you think it is an aggressive program?

Mr. FLOBERG. I think it is aggressive. I think it is as aggressive as the scientific foundations for the program justify. It is not a helter-skelter program or anything of that sort, and I don't think it should be.

Representative PRICE. Do you call a program that has been cut back aggressive?

Mr. FLOBERG. It has not been cut back. It is starting from zero.

Representative PRICE. It is starting from zero because we reached zero just a few months ago.

Mr. FLOBERG. We never had a program.

Representative PRICE. Of course, the situation is inherited by the Commission.

Mr. FLOBERG. You are asking me is the Commission's program accelerating.

Representative PRICE. I am talking about the civilian program.

Mr. FLOBERG. I think the answer is that there was no civilian program up until recent months. Now there is one and it is starting.

Representative PRICE. It was inherited from the Army and now becomes the civilian program. But the overall program of food irradiation was considered to be an aggressive program during the past year or so.

Mr. FLOBERG. During the past year?

Representative PRICE. Yes.

Mr. FLOBERG. I think the basic research that has been done on this has been conducted aggressively. I think that part of the stigma that attaches to recent decisions in connection with this program has to do with premature decisions that were made a couple of years ago with regard to the Stockton construction. I think that was a premature decision at the time it was made, and the cancellation was a wise decision. But it does mean a cutback in the level of effort that is devoted to it. I would say it was a pretty good decision to cut it back.

Representative PRICE. You think it is not far enough advanced to put more effort into it?

Mr. FLOBERG. It is not far enough advanced to build a pilot plant.

Representative PRICE. The purpose of the pilot plant, Mr. Floberg, was to advance research.

Mr. FLOBERG. I think there is a lot of work to be done before we will know how to build that pilot plant.

Representative PRICE. The purpose of the pilot plant was to make the work easier.

Mr. FLOBERG. It would be my opinion, Mr. Price, that would not be the best or most economical way to go about it.

Representative PRICE. I am only taking the presentations made before this committee by the previous custodians of the program, the Army. They stated a need for this pilot plant to develop this research.

Mr. FLOBERG. I certainly don't question your statement. I think it was oversold.

Representative PRICE. Dr. Aebersold, would you mind commenting on whether or not you think we are now going into an aggressive program?

Dr. AEBERSOLD. I think it is important to differentiate between the low dose treatment program and the high dose treatment program. The Army has done quite a bit of exploratory work in the low dose field. But the amount of money they spent, as I understand it, using Army funds, has been at about $150,000 a year on food technology related to low dose treatment.

The Army has conducted wholesomeness tests in the low dose areas on four representative food items: flour, citrus fruit, potatoes, coleslaw.

These items were selected for test by the Quartermaster Corps for two reasons. First, they were part of the 21 foods selected for the wholesomeness testing program which were considered to be representative of the major classes of foods research on which would yield data that could be extrapolated to other foods in the same classes. Second, they were selected as items which would complete a balanced diet for use in the human feeding tests in which it was planned to serve 100 percent irradiated meals to volunteers. The four items referred to were not selected on the sole basis of relation to the military ration.

They have also conducted some wholesomeness tests in the low dose area, but only on four food items: flour, citrus fruit, potatoes and cold slaw. Those were items selected by the Army as of interest for a military ration. They are not items of fish or fruit that we believe are of interest in commercial marketing activities.

Representative PRICE. What food area is the Commission going to work in?

Dr. AEBERSOLD. As we indicated, fruit and fish. This budgetary level in fiscal year 1961 we show here would be at least twice the amount of Government money spent on low dose treatment on the average in the past.

Representative PRICE. Are there any questions?

Representative VAN ZANDT. Commissioner Floberg, who recommended the creation of the Interdepartmental Committee?

Mr. FLOBERG. I haven't the slightest idea. I will have to ask Dr. Aebersold.

Representative VAN ZANDT. The ad hoc committee, I should have said.

Mr. FLOBERG. This was done at the Army initiative, I am told.

Dr. AEBERSOLD. The Interdepartmental Committee itself was established by the Army. The ad hoc panel was established by the Interdepartmental Committee.

Representative VAN ZANDT. Who recommended the creation of this group?

Dr. AEBERSOLD. The ad hoc panel?

Representative VAN ZANDT. Yes.

Dr. AEBERSOLD. When the Army announced its plans for cancellation of the Stockton facility, some members of participating agencies in the Interdepartmental Committee got together and decided it

would be desirable to have a meeting on the question of where does the irradiated food program go from here, and particularly, if the Army cancels certain elements of its program, what becomes of the civilian activities.

Representative VAN ZANDT. Who was the chairman of this committee?

Dr. AEBERSOLD. I was, sir.

Representative VAN ZANDT. Are you in accord with the recommendations of the committee?

Dr. AEBERSOLD. This was a technical group, and our recommendations were things that we thought were technically desirable. The question of how fast one can do them is something that technical men cannot always decide.

Representative VAN ZANDT. Are you in accord with the recommendations of the committee?

Dr. AEBERSOLD. In general.

Representative VAN ZANDT. Doees that mean there are some areas of the report you do not concur in?

Dr. AEBERSOLD. No, sir; I mean that with a panel of people it is compromise to get agreement on all factors.

Representative VAN ZANDT. Did the committee recommend that the AEC accept leadership?

Dr. AEBERSOLD. They did, sir.

Representative VAN ZANDT. Did the committee recommend that the AEC accept the leadership based on the fact the AEC has the laboratory facilities and the personnel to do the job?

Dr. AEBERSOLD. No, sir. I believe it was because of the AEC's background in radiation technology. Also, the fact that it is a desirable part of the President's atoms for peace program seemed to make it fit in more as an AEC activity.

Representative VAN ZANDT. What part is the AEC going to play in the program as it has been revealed to us today?

Dr. AEBERSOLD. I would say it would be taking leadership in the low-dose treatment area of civilian commercial interest.

Representative VAN ZANDT. You are going to take leadership in the low-dose area.

Dr. AEBERSOLD. Yes, sir.

Representative VAN ZANDT. Does this mean that the AEC will add a lot of vigor to the effort?

Dr. AEBERSOLD. I think we are adding vigor to the effort.

Representative VAN ZANDT. In other words, what you have demonstrated here today is the result of AEC thinking?

Dr. AEBERSOLD. We must recognize that we are selecting for detailed study a very limited number of food items so that the dollars expended per food item may be larger here than expended previously. If we pick four fruits and four fish and pay all of our attention to learning evereything we can about these, we expect to be further off than if we spread our effort over a large number of items. How much money per year is required depends on how many items you want to study at one time. Whether you want to study shrimp and crab at the same time, or whether you think they can be studied in sequence is a matter of judgment.

Representative VAN ZANDT. Are you in a position, Doctor, to tell us how many food items were selected for bombardment prior to the cancellation or the slowing down of the program last fall?

Dr. AEBERSOLD. Sir, the Army's testimony this morning revealed that they did not slow their research activities. They were still carrying on some low-dose studies. However, in the case of certain items, such as fish, I think the activity was very low last year. We learned that the Army had become more interested in concentrating their effort on meat. When we became aware of this last fall, even before learning about the cancellation of the Stockton facility, we initiated studies of what could be done in the field of irradiation of fish. That resulted in the report, the MIT report, furnished your Committee on Irradiation Preservation of Fish.

Representative VAN ZANDT. Let me repeat my question now. How many food items were approved in the program?

Dr. AEBERSOLD. In the Army's program?

Representative VAN ZANDT. Yes. Was is not something like 80 or 85?

Dr. SIU. The total number of items in the initial survey, Congressman Van Zandt, was over 100 foods. We tried to bracket them as to which foods are generally very difficult, which foods are generally moderately difficult, and which foods are relatively easy. Based upon that we concentrated on those foods that are moderately easy to relatively difficult in the sterilization dose for the Army ration. For the low dose treatment, we tried to interest other agencies. The Department of Agriculture got interested in some of the fruits, and you noticed the Commission's testimony that out of our survey they have now narrowed down the range for immediate attention.

Representative VAN ZANDT. You made a study of over 100 different types of food?

Dr. SIU. That was a survey, sir.

Representative VAN ZANDT. How many did you find would stand up under the bombardment, whether the high dose or the low dose?

Dr. SIU. If you excuse my free handing, I would say about 30, sir. This does not take into account the possibility that future research may enlarge the number.

Representative VAN ZANDT. Does it mean Doctor: We are going to forget some of the items included in the 30 and concentrate on the items mentioned here today.

Dr. SIU. I would not like to speak for the Commission concerning this question, so I am at a loss as to how to approach your question. I would say this, though. In the area in which the Army is concerned, in the high dose sterilization, we will take care of all the meat. We will probably also in agreement with the AEC, take care of low dose treatment of some of the cured meats, because with the low dose treatment of some of the cured meats the shelf life can be extended to several months. That length of extension is well within the Army's interest in military rations.

Representative VAN ZANDT. Then I understand the Army will handle the meat, either fresh or cured.

Dr. SIU. Yes, sir.

Representative VAN ZANDT. And the AEC will handle fish and fruits?

Dr. SIU. Low doses, yes. As the Army's high dose studies for military purposes show that there is a civilian possibility—let us say a brown and serve roast chicken, sterilized—the AEC will then make the attempt to introduce that to the civilian market. In the AEC's low dose studies of fruit, for example, if the AEC is able to extend the shelf life of citrus to a period of several months, the Army would be interested. We would continue from the AEC's results and produce the necessary military specifications and applications and engineering transmission so that the Army can integrate it into its supply system. We have such an agreement worked out in this joint program.

Representative VAN ZANDT. What is going to happen to the program involving the elimination of insects as far as flour and beans and sugarcane and so forth are concerned?

Dr. SIU. The low dose irradiators that the AEC is talking about will be ideal for that type of research. I must speak only from the standpoint of personal acquaintance and not officially for the Department of Agriculture, but the Department of Agriculture is studying this possibility. I understand there is some preliminary investigation in the 50th State of the Union on the possibility of killing the insects in certain tropical fruit to pass quarantine restrictions.

Representative VAN ZANDT. That will not be involved in this effort.

Dr. SIU. It is very closely coordinated, sir. The Department of Agriculture and the AEC are working hand in glove.

Representative VAN ZANDT. What about the elimination of fungi as far as clothing or leather is concerned, and the elimination of moths?

Dr. SIU. That is beyond this program, sir. But we are doing some work on a very low level in our laboratories.

Representative VAN ZANDT. That is not related to this program.

Dr. SIU. No, sir.

Representative VAN ZANDT. Commissioner Floberg, in connection with the irradiation of milk, have you been able to correct the taste factor?

Dr. AEBERSOLD. Sir, no one in the Commission has really worked in this field at the present time. The Commission's interest in food irradiation started around 1950. As you know, as the Army took over this program in 1954, the Commission has not contracted for actual food technology studies. That question will have to be answered by the Army.

Representative VAN ZANDT. Can Dr. Siu answer the question?

Dr. SIU. With regard to the flavor of irradiated milk, I assume you are referring to the high dosage for sterilizing milk, there has been developed a technique of eliminating the off flavor, sir, by countercurrent aeration—drawing a stream of air through the milk under the sterilization field, thereby drawing off the off flavors. However, the irradiated milk does jell and brown more rapidly than the normal. So although they have overcome the flavor changes to a large degree, the other effects have not been resolved. As of this moment I would not say that you can sterilize cow's milk effectively with irradiation. With regard to the specific flavor change, however, that has been overcome to a considerable degree.

Mr. FLOBERG. I would make a gratuitous observation and that is pasteurization itself spoils the flavor of good milk enough. I hope irradiation won't spoil it more.

Representative VAN ZANDT. I understand exposure of milk to radiation produces a taste somewhat similar to garlic. So the problem is acute in many ways.

Commissioner, you mentioned in your statement that other countries are carrying on research in this field. How extensive is it?

Mr. FLOBERG. Dr. Aebersold is familiar with the other programs. I will ask him to answer your question.

Dr. AEBERSOLD. A large number of the European countries and some other countries of the world are engaging in research and development largely in the low-dose treatment or practically entirely in the low-dose treatment area. England has, I think, the largest program in that. They already have irradiator similar to the one I have shown for the high-intensity radiation development laboratory. They have one in operation and are actually irradiating food packages of commercial interest.

Representative VAN ZANDT. What are the items? Are they confining their efforts to meat and to fish and to fruit?

Dr. AEBERSOLD. They are doing an exploratory program which covers almost all types of food items. But they are also concentrating on the items that the Army's exploratory program has shown to be in the moderate difficult class. In other words, the rest of the world has leaned heavily upon the work done by the Department of Army. So in that respect the Department of Army has done a good service in the atoms for peace program in pointing the way in which food items are the most promising.

The British have followed along that line and so have other countries. In some countries, there are specialized interests. In the Mediterranean countries it is more citrus fruit. Scandinavian countries' interest is more to fish. I would say probably 15 countries of the world are doing low-dose research with food.

Mr. FLOBERG. Mr. Van Zandt, on page 178 of the printed record of the previous hearings there are some references to the foreign programs and some of the things that are being done in other countries.

Representative VAN ZANDT. That is all, Mr. Chairman.

Representative PRICE. Mr. Bates.

Representative BATES. Mr. Aebersold has written some splendid papers on these fish studies. I wonder if he has any remarks he wishes to make in addition to the ones he previously made?

Dr. AEBERSOLD. Sir, I didn't develop this information. We understood that the MIT food technology laboratory had done some exploratory work, I believe, under contract with the U.S. Army in the field of fish irradiation. We contracted with them last year to make an analysis of what had been done in this field. This is the basis of this report here which you have as appendix 5 of part I of this hearing.

Incidentally, if I may compliment the Joint Committee staff, I would like to do so. I found this document, the proceedings of the January 14 and 15 hearings, to be one of the best sources of information on food irradiation. The appendixes to this are very, very useful, and I think will be valuable to interested people throughout the world. The Joint Committee staff has done an excellent job in getting all this information together.

For those interested in the fish field I believe it would be worth while to read the summary in appendix 5 (pt. 1, p. 634).

Representative BATES. What page is that on?

Dr. AEBERSOLD. Page 634. Actually, the abstract is on page 630.

Representative BATES. Where do we stand today in respect to MIT and that contract? Commissioner Floberg indicated that they are making an economic study to be completed some time this summer.

Dr. AEBERSOLD. Yes.

Representative BATES. Are they continuing the basic experimental work?

Dr. AEBERSOLD. They are completing this analysis and survey. The version you see printed here is a draft. They will finish this and add to it much more technical data. The final report will be finished in late April. We have extended the contract for the purpose of detailing an integrated experimental program for the development of radiation preservation of fish. This contract will outline in detail the experimental work on fish to be performed using the radiation sources and irradiators which are recommended for the program. This will outline the program for the next 5 years in the study of radiation preservation of fish.

Representative BATES. How would this tie in with the two mobile irradiators? Would MIT have it or would we send it down to Natick?

Dr. AEBERSOLD. If the Army builds a facility at Natick it would be useful for the civilian fish irradiation program.

Representative BATES. Do you believe that we ought to have a facility in the Boston area for fish purposes?

Dr. AEBERSOLD. We need two types of facilities. One would be the small research irradiator of the type which I have shown schematic drawings of, using 10,000 to 20,000 curies of cobalt, which would allow our low-dose food studies to go ahead. These would permit studies of flavor and texture change, and so on. Later one needs a larger irradiator to irradiate actual quasi-commercial-type packages because one of the parts of the evaluation is to irradiate enough fish to study spoilage on a statistical and commerciallike basis. All fish or fruit in any large batch do not spoil simultaneously; some spoil one day, some the next, etc. You need to irradiate enough items to get good statistics under actual spoilage conditions about average extension of shelf life.

Representative BATES. When we say shelf life, we mean 35° F.

Dr. AEBERSOLD. Yes, sir.

Representative BATES. You would still have to ice down the fish?

Dr. AEBERSOLD. Yes, sir.

Representative BATES. It would last longer.

Dr. AEBERSOLD. That is right.

Mr. FLOBERG. The availability of the Army facility at Natick would obviously have a degree of relevance to the future facilities program of the Commission and the degree to which the Army occupied that facility or the degree to which they could make it available to the Commission would be an important factor in any decisions the Commission had with regard to bricks and mortar.

Representative BATES. So you would work hand in glove with the Army at Natick?

Mr. FLOBERG. We would certainly hope so, and we would assume the Army's cooperation within the limits of their ability to cooperate under their own programing.

Representative BATES. I wonder if the doctor could comment on the progress that has been made in the chemical field in the preservation of fish?

Dr. AEBERSOLD. I would like to make this comment first. In developing any of our programs we have worked very closely with the other agencies interested. For example, in the case of fish, the Bureau of Fisheries of the Department of the Interior. For example, our MIT contract calls for close cooperation with the Bureau of Fisheries. I would prefer that the members that are here from the Bureau of Fisheries comment on your question. As I understand it, the interdepartmental committee chairman and his experts will testify later and they can testify on the matter of the other methods of preservation of fish. However, by working with them, we will integrate our program into all the other methods of extending the shelf or storage life of fish.

Representative BATES. If they will testify later, I will let it go until that time. As far as you have gone in this field now, do you have any indication at all of the economics of this?

Dr. AEBERSOLD. This will be one of our startup studies, to try to find out what needs to be done. For example, what is the desirable extension of shelf life. The Army is interested in the maximum period you can extend the shelf life. We would like to know what is a desirable commercial extension of shelf life. Is 1 week enough, or should it be 3 weeks or longer? It will vary with products. It will be different for fruit than for fish. Until one knows this, one doesn't know what practical dose is needed. Until you know what dose you need and the number of tons to be processed per day, you can't design an irradiator, because the design is very dependent upon the total dose and the number of tons of throughput. Very early in this program, therefore, we have to make a study, or have made for us by Stanford Research Institute and MIT, the commercial patterns of marketing fish and fruit.

Representative BATES. Could you give any estimate, and I realize it would have to be very rough, of what the cost might be commercially of these irradiators after they get into production?

Dr. AEBERSOLD. This depends upon whether you have small or large processing centers. It is our understanding that in the case of fish, there is only one company in the United States that has as large as 1,000 employees used in the processing of fish. We have to look into whether one would establish small individual company irradiators or a large commercial radiation facility where all the fish processors in a local region could bring their fish for radiation processing, similarly to the facilities for freezing of fish which I understand are used commonly by groups of fish processors.

Mr. FLOBERG. I don't see how, with the limited knowledge we have of this thing, we would be in any position to talk about production line techniques. That is what you really are talking about.

Representative BATES. Yes. The only reason I asked the question is that originally when this developed, all kinds of folks had all different kinds of concepts. They even thought of putting it on a

boat. If you could do that, you could cut down on the ice or eliminate the ice and each boat could afford to have one. We are reaching the stage now where that does not appear likely. In a place like Gloucester, which is the largest port in the United States for catching fish——

Mr. FLOBERG. Where is that place?

Representative BATES. Gloucester, Mass. In a place like that, you would have one facility which would process all of the fish?

Dr. AEBERSOLD. That is possible. That is one of the things we need to look into.

Representative PRICE. Mr. Floberg, perhaps we are a little impatient of getting this show on the road because of the delays from time to time. You may well be right that you have to start the program gradually. Has your planning for the 5-year program gone far enough that you know whether most of the recommendations for facilities mentioned in the ad hoc Interdepartmental Committee's recommendation are included? This is over the 5-year period.

Mr. FLOBERG. I think that the analysis would show that there is nothing that looks wholly outrageous in the recommendations of the committee.

Representative BATES. I mean being specific, such as they recommend four irradiators and you have only two in your program now. You don't have any of the mobile irradiators and they recommend two. They make other recommendations. Four research irradiators. Are they included anywhere in your 5 years planning program?

Mr. FLOBERG. They are included, but you can't say they are definitely programed. I would say in the case of the mobile irradiators, for example, there is a pretty good chance that we will get into the mobile irridiator picture. Just when I don't know. I would doubt, as I said before, that we would be prepared to get into it in fiscal year 1961. Any one item in the ad hoc panel's report can be disputed. But that does not mean that the report is an invalid one. It means that the people expressed their opinions at that time, and they are reasonable opinions and other people can differ with them and still be reasonable.

Representative BATES. You plan to spend over $5 million in the 5-year program. Certainly that will entail the construction of some facilities.

Mr. FLOBERG. Yes.

Representative BATES. You must use some planning to arrive at the figure of $5 million.

Mr. FLOBERG. This is 5 million operating dollars. That is what these figures are on this chart.

Representative PRICE. What about facilities? Where is money for these facilities coming from?

Mr. FLOBERG. The mobile irradiators would come out of this because they are in the category of equipment rather than facilities.

Representative PRICE. The specific ones we are talking about come out of operation.

Mr. FLOBERG. Yes, sir; that is the fiscal technique.

Representative PRICE. As I look at it now, you told us pretty well what your program is to start the AEC civilian program. As I look at it, the things that are left that were recommended by the ad hoc

panel include four research irradiators, which were proposed for the conduct of fundamental studies which they said would be necessary for the development of irradiation-processed food. Then leaving out both mobile irradiators which were for the purpose of processing fruits, vegetables and grains, particularly in the infestation of grains that Mr. Van Zandt talked about. You are leaving out the fixed irradiators for the marine products. Is that correct?

Mr. FLOBERG. When you say leaving out?

Representative PRICE. You are not acting on these recommendations. You are not asking for appropriations for these recommendations of the ad hoc panel?

Mr. FLOBERG. We are not following the time schedule that the ad hoc panel laid out for these things. Whether we will follow the actual item recommendation is a different subject.

Representative PRICE. But even though you planned it on a 5-year basis, you don't know definitely whether this program is projected far enough so you can see these facilities in the program.

Mr. FLOBERG. These look like reasonable projections but the answer to your question is "No," and it has not gone so far that we can guarantee that they ever will be.

Representative PRICE. Or the other.

Mr. FLOBERG. That looks reasonable but it is hard to be concrete about it.

Representative PRICE. I want to be clear on the two figures you have on the AEC funding for fiscal year 1956. The $115,000 is from funds you expect to find somewhere else in the program and will allocate to the food irradiation program?

Mr. FLOBERG. This is money that is in the Office of Isotope Development. The money is that which is earmarked for isotope applications of one sort or another. It will be devoted to this particular phase of the isotope program.

Representative PRICE. Could you tell how the isotope funding is at the present time? Have you had any cutbacks of funds for this program?

Mr. FLOBERG. You mean of a supplementary nature?

Representative PRICE. Yes.

Mr. FLOBERG. No, sir; there have been no requests for supplemental funds.

Representative PRICE. You have sufficient funds that will stand additional tapping?

Mr. FLOBERG. This will be determined on the basis of priority of program and something else will be evaluated as less urgent than this program.

Representative PRICE. The $115,000 is not too disturbing. But when you get to the next year, the half million dollars, if you were to take it from a fund that has already suffered from too little support, it would be serious. I hope the Commission does not do that.

Mr. FLOBERG. I hope we do not, too. Once again a good part of this money will obviously have to be furnished by the Office of Isotopes Development and we will put a hammerlock on Dr. Dunham for some of it from his otherwise available funds, and we will try to do this without damage to any other program and certainly without damage to any programs of high priority.

Representative PRICE. Thank you very much, Mr. Floberg.

Mr. FLOBERG. Thank you, Mr. Price.

Representative PRICE. We appreciate your appearance and are always glad to have you before us.

(Correspondence between the Joint Committee and AEC pertaining to the food irradiation program follows:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., March 7, 1960.

Hon. JOHN A. MCCONE,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR MR. MCCONE: On January 14, 1960, the Joint Committee held public hearings on the decision by the Department of the Army to cut back on its food irradiation research program. During the hearings, we discussed the report of the ad hoc panel of the Interdepartmental Committee on Radiation Preservation of Food which report, in draft form at that time, contained recommendations for the formulation of a national civilian program with the Atomic Energy Commission designated as the operating agency.

The final ad hoc panel report has been received by the Interdepartmental Committee and submitted to the interested agencies, including the Department of the Army and the Commission. I would hope that appropriate action can now be taken without further delay to carry out the recommendations of the report and that the Commission would be prepared to proceed immediately to carry forward a vigorous program.

As you know, the Joint Committee was quite disappointed and somewhat disturbed by the manner in which the Department of the Army in October 1959 suddenly announced its decision not to proceed with the Ionizing Radiation Center. Previously in 1955 and 1956, representatives of the Commission and the Department of the Army had testified favorably as to the economics and objectives of the program and had informed the committee that construction of the center would commence in 1957 and that it would be in operation in 1958.

Thereafter the Joint Committee was not properly kept "currently and fully informed" as to the program, particularly as it failed to proceed as scheduled and along the lines the committee had been led to expect. The hearing on January 14, 1960, for example, brought out that construction of the center never even commenced. It was ascertained that decisions were made by the Department of the Army without proper interagency coordination and that the decision to cancel construction came as a surprise to the AEC as well as the Joint Committee.

The Joint Committee hearing on January 14, 1960, also developed the fact that no adequate scientific data supported the Army's determination to cut back on the program. A report by the A. D. Little Co., which was "used partially as a basis" for the Army decision to cancel was not even read by the technical director of the project. The Army, in a letter to a Member of Congress a few days before deciding to cancel the project, went so far as to say that "progress has been substantial and encouraging and the program is now ready for the pilot-plant testing phase."

Whether or not the Army was justified in its decision either from a scientific or economic point of view, I believe it is of the utmost importance that the United States move ahead with a definite food irradiation program. I believe the Government should proceed to establish a food irradiation center and that necessary attention should be given immediately to this matter in order that authorization and appropriation legislation could be considered during this session of the Congress. Since the Department of the Army for one or more reasons decided not to follow through with the original objectives, I believe the Commission is the proper agency to support this program in cooperation with private citizens and companies interested. The Joint Committee would endorse the assignment of the food irradiation program to the AEC and would be prepared to support a vigorous program to further the development of this concept of the peaceful atom.

The failure of our Government to adequately support the food irradiation program, I believe, is merely symptomatic of our entire atoms-for-peace program. The many glowing promises which were made to the world during the period 1953–56 have not been fulfilled. It may still not be too late. We cannot, however, afford to waste any more time nor to make promises to our free world friends that are not being supported by our actions. The Commission today, I believe,

should be in a position to go ahead with the program and endeavor to put it back into operation and further its advancement.

I have discussed the above with my colleagues on the Joint Committee, Congressmen Carl T. Durham, Chet Holifield, Mel Price, and James Van Zandt and they advise me that they concur in my views.

I am sending a copy of this letter to the Secretary of the Army.

Sincerely yours,

CLINTON P. ANDERSON, *Chairman.*

U.S. ATOMIC ENERGY COMMISSION,
March 9, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR SENATOR ANDERSON: At the January hearing on radiation preservation of food, the Joint Committee was advised that the Commission would soon consider the report of the Interdepartmental Commitee on Radiation Preservation of Food. Commissioner Floberg agreed to advise the Joint Committee on the Commission plans with regard to a radiation processed foods program.

Attached is a summary statement of this program, as approved by the Commission, including expenditure levels for fiscal year 1960 and fiscal year 1961.

Sincerely yours,

A. R. LUEDECKE, *General Manager.*

SUMMARY STATEMENT OF AEC RADIATION PROCESSED FOODS PROGRAM

1. The AEC has approved the fiscal year 1960 and 1961 phases of a 5-year low-dose radiation processed foods program. This program will include basic studies devoted to determining and resolving problems in food chemistry, microbiology, and wholesomeness which may result from irradiation, as well as establishing radiation process technology, economic feasibility and marketability. A program of at least this duration is needed to obtain sufficient data to determine if there are toxicological, carcinogenic or related problems with foods processed by low doses of radiation. It is presently estimated that the 5-year program costs will be about $5 million.

2. The immediate objective of the radiation processed foods program will be to concentrate on a small number of selected food products which appear to promise early technical feasibility and market acceptance. It is expected that establishment of technical feasibility and market acceptance of a few radiation processed foods will prompt industry to extend independently the technology throughout the broad spectrum of food products.

3. The AEC radiation processed foods program is consistent in scope and with the objectives of the Interdepartmental Committee on Radiation Preservation of Food Report.

4. Because of the time required to establish the specific details of a sound integrated program, however, it does not appear feasible to proceed initially as rapidly as suggested in the Interdepartmental Committee report.

(*a*) Initial startup studies must be completed to establish the specific elements of a research program on wholesomeness and safety of low-dose processed foods, including interrelated work such as radiation effects, process and preservation factors for shelf life extension, as well as selection of specific foods for study under the program.

(*b*) These considerations involve specific identification with the Food and Drug Administration of the scientific protocol to be followed in the establishment of safety of low-dose radiation processed foods and their final clearance.

(*c*) It is expected that development of a fully defined research and wholesomeness program will require approximately 6 to 8 months for completion.

5. The AEC program provides for two laboratory research irradiators through fiscal year 1961. The research irradiations (containing ten to twenty thousand curies of cobalt 60) will be used to carry out basic studies to establish wholesomeness and safety of low-dose radiation processed food, as well as to investigate the origin and control of factors affecting the food's odor, taste, color, and texture. The need for additional laboratory research irradiators, as well as for

other types of irradiators, such as mobil units, will be determined as the Commission's program becomes more fully developed.

6. The AEC food program presently envisions partial use of the high-intensity radiation development laboratory currently authorized for construction at the Brookhaven National Laboratory for conduct of future experimental work related to product and process development. This use would require limited modification of the facility. It is to be noted, however, that the Brookhaven facility, as originally authorized, will be used primarily for radiation source and engineering development, as well as radiation studies on chemical systems, etc.

7. Commercial food processing companies will be actively encouraged to participate in the proposed program through radiation study agreement where the Government provides the service of irradiation of food and industry performs without cost food research and evaluation.

8. The Commission has approved expenditure of funds in the amount of $115,000 in fiscal year 1960 and $500,000 in fiscal year 1961 for initial activities of this new program. The details of the planned program are set forth below. The subprogram fund allocations would be subject to revision as the program develops.

	Fiscal year 1960	Fiscal year 1961
Initial activities and studies [1]	$75,000	$100,000
Research irradiators	40,000	40,000
Food chemistry		200,000
Microbiology		
Supplementary wholesomeness		
Preservation factors		50,000
Nuclear effects		25,000
Packaging development		25,000
Commodity procurement		10,000
Irradiation services		50,000
Total	115,000	500,000

[1] A brief description of each of the following activities is set forth in par. 9.

9. A description of the major elements of the AEC radiation processed foods program are set forth below:

(*a*) *Initial activities.*—To intelligently pursue the radiation processed foods program, it is necessary to undertake certain initial activities. These include (1) collection and analysis of Army research and development work to date relevant to the civilian program; (2) identification of specific food products promising technical, economic, or marketing advantages through radiation processing and research and development work required to develop them, and (3) design of irradiators.

(*b*) *Food chemistry.*—Radiation causes various chemical, vitamin, nutritional, and organoleptic (odor, color, taste, texture) changes in food. Studies are required to identify precisely the nature and extent of these changes.

(*c*) *Microbiology.*—Spoilage by micro-organisms is often the prime cause of rapid spoilage of foods. The purpose of radiation processed is to destroy or inhibit these micro-organisms. This requires study of radiation resistance of numerous spoilage micro-organisms common to foodstuffs, so as to determine radiation dosage for their growth inhibition.

(*d*) *Supplementary wholesomeness.*—The Army has been conducting and is expected to complete a definitive wholesomeness and safety program on radiation sterilized food. Although this program will contribute information of value for low-dose radiation processed foods, additional wholesomeness and safety studies will be required to obtain FDA clearance for foods of interest in the civilian program.

(*e*) *Preservation factors.*—It is necessary to be able to routinely and reproducibly obtain acceptable radiation processed food products. This requires study of the effect of variation in irradiation conditions such as total dose, humidity, irradiation time, etc., on acceptability of a product.

(*f*) *Nuclear effects.*—Use of radiation for food processing entails study of unique factors not encountered in conventional food processing. These include possible effects on food depending upon the rate at which the radiation is

delivered, investigation to assure absence of induced radioactivity in food, and evaluating systems for precisely measuring radiation dosage delivered to the food.

(*g*) *Packaging development.*—This involves development of food packaging materials that are radiation resistant, do not transmit toxic additives to the food, and are suitable for marketing purposes.

(*h*) *Commodity procurement and shipping.*—This involves obtaining and transportation of foods required to carry out the foregoing research and development.

(*i*) *Irradiation services.*—A number of private organizations have cooperated in the Army food program by evaluating irradiated foods without charge. It is expected similar arrangements can be made in the civilian program. This item thus reflects cost of irradiating foods which are thereafter evaluated by private groups without charge.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 24, 1960.

HON. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR SENATOR ANDERSON: Just prior to receipt of your letter of March 7, 1960, concerning the food irradiation research program, the Commission forwarded to the Joint Committee the outline of the radiation processed foods program which the Commission had just approved. Although the Commission's radiation processed foods program is not identical with the program recommended by the Interdepartmental Committee on Radiation Preservation of Foods, it is consistent with the latter program in both size and scope. Adjustments have been made to recognize the passage of time and to increase emphasis on fundamental studies, such as wholesomeness. We will be happy to explain the new program in greater detail at the hearings of the Subcommittee on Research and Development on March 31, 1960.

Your letter comments at length on the decision of the Department of the Army not to proceed with the Ionizing Radiation Center at Stockton, Calif. As explained at the hearing on January 14, the proposed Ionizing Radiation Center was a Department of the Army funded project. The Commission participated in the project only to the extent of awarding and administering a contract, with Army funds, for the design and construction of a cobalt 60 irradiation facility for the center.

Since your letter of March 7, the Army has reached some decisions concerning the future of its high-dose radiation processed foods program and its plans for a food irradiation research and development center. The revised Army plans have now been given to the staff of the Joint Committee. It is apparent, from these plans, that the Army's program on high-dose radiation processing of foods will constitute a program which is complementary to the newly established Commission low-dose radiation processed foods program. The Commission has been informed by the Department of the Army that the latter's proposed research and development facility will be made available for use in the Commission's radiation processed foods program.

As stated in our letter of March 9, 1960, the Commission's radiation processed foods program does not currently envision the need for constructing a food irradiation center. During the initial 6 to 8 months of the Commission's program, studies that will be conducted should indicate more clearly the nature of the irradiation facilities needed for the Commission's program. At present, it appears that small irradiation facilities, located in several areas of the country near food sources, may be more useful in the Commission's program than would one research center.

The Commission's radiation processed foods program will concentrate on low-dose processing of food. Both the Commission and the Interdepartmental Committee believe low-does processing to be of greatest interest to the civilian economy. Since the Army has now decided to proceed with its own high-dose radiation processing program, the Commission does not believe that it should be given overall responsibility for a national food program that would include

both high- and low-dose processing. The Commission and the Army have taken steps to establish strong liaison between the two agencies in the radiation processed foods programs.

The Commission believes that the radiation processed foods program of the Commission, together with the Army's program, will constitute the basic elements of an aggressive national program. We anticipate that other governmental agencies will wish to augment the program and participate actively therein. We feel that the result will be an aggressive national radiation processed foods program for a linear accelerator is less apparent, however. It appears that requirements

Sincerely yours,

JOHN MCCONE, *Chairman.*

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., April 14, 1960.

HON. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR SENATOR ANDERSON: During the March 31, 1960, hearings on the "National Food Irradiation Reseach Program," you raised a question in regard to a statement in a letter dated December 11, 1959, from the General Manager to the U.S. Army Quartermaster General, which read as follows: "The necessity for a linear accelerator is less apparent, however. It appears that requirements relating to study of induced radioactivity can probably be fulfilled with existing facilities. With information presently available to us, we could not concur in the need for a linear accelerator at this time."

You asked whether this statement represents the position of the AEC or not. You also asked me if I was sure that General Luedecke's letter was written about the earlier Army program or the revised program because General Luedecke stated in his letter of December 11, 1959, that the Atomic Energy Commission appreciated the opportunity to review the draft revised Army program.

In direct answer to your questions, at the time of my testimony, the quoted statement no longer represented the Commission's position. Further, at the time General Luedecke's letter was submitted, you were correct in your assumption that we had reviewed an early draft of the Army's revised program.

In amplification, I would like to acquaint you with the background of this matter. It was our understanding, when we reviewed the revised Army program, that the accelerator included in the program would be used for the production of radiation processed food as well as for a research tool, even though the Army was planning on redesigning it from 24 million electron volts to 12 million electron volts.

In subsequent discussions with the Army personnel this point was clarified when the Army people explained that it was their intention to use the accelerator as a research tool only and at least for the present, not to produce irradiated foods. There are certain advantages, as discussed in the Army revised program, in the flexibility that such a machine has for some aspects of research work over a cobalt 60 source.

In these discussions the Army also made it clear that they were aware of the position taken by the Food and Drug Administration and the Army Surgeon General that the use of electron energy levels above 5 million electron volts for production of radiation processed food should not presently be considered because of problems of induced radioactivity. While their machine will be designed for electron energy levels of 12 million electron volts, it appears from Mr. Morse's testimony that they seldom would exceed energy levels of 5 million electron volts.

In view of the above clarification of the Army's program, as brought out in discussions subsequent to General Luedecke's letter, it is now the Commission's feeling that such an accelerator would be a useful research tool, and the Commission on this basis supports the use of this type of machine, within the limitations outlined above, in the Army's revised program.

Sincerely yours,

JOHN T. FLOBERG, *Commissioner.*

(A letter dated April 11, 1960, from James T. Ramey, executive director, JCAE, to the AEC, requesting additional information, and the AEC response, follow:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., April 11, 1960.

Gen. A. R. LUEDECKE,
General Manager, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR GENERAL LUEDECKE: The Subcommittee on Research and Development on March 31, 1960, held a public hearing at which Commissioner Floberg and other representatives of the Atomic Energy Commission discussed the Commission's civilian radiation preservation of food program.

In order that the record may be more complete, it would be appreciated if the Commission would provide the following additional information to the subcommittee:

1. The planned date for completion of construction of the Brookhaven National Laboratory High Intensity Radiation Development Laboratory. When will it be available for carrying out irradiation studies on products such as foods?

2. The extent to which Brookhaven will participate in the Commission's low-dose radiation processed foods program. Does the Brookhaven National Laboratory have available currently technical capability in food technology and supporting research facilities sufficient to carry out a major part of the Commission's radiation processed food program?

3. The Commission testified during the hearings that for low-dose radiation processing it is desirable to have the irradiation facilities in close proximity to the food production area. Does the location of the Brookhaven National Laboratory lend itself to effective use in your planned food research projects on fish and fruit?

4. In the Commission's opening statement reference was made to plans for initiating research on wholesomeness and safety of low-dose radiation processed foods during the latter part of fiscal year 1961. It was further stated that irradiators of the mobile type would have a sufficient product throughput to supply food requirement for animal feeding studies under the wholesomeness program. Accordingly, we wish to determine what the Commission's current program planning is for irradiation facilities in fiscal year 1961 to meet the requirement for supplying needed radiation processed foods for wholesomeness research. Can this be accommodated by the laboratory research irradiators currently programed; or will this require other types of irradiation facilities such as mobile units?

5. During the hearings, the Commission identified that two laboratory research irradiators are to be designed and constructed as part of the currently approved AEC food program. The testimony did not specifically identify, however, when these research irradiators would be available for use in the food program nor their production capacity. Accordingly, we request specific information on these points as well as an indication of where the irradiators will be used and for what purposes.

6. The Commission's opening statement indicated that as current studies to specifically define the radiation processed foods program are completed requirements for additional research irradiators, as well as for more specialized types of irradiation facilities, would be established. As these requirements for irradiation facilities become known, the committee wishes to be specifically informed of this.

7. We noted in the Commission's prepared testimony that an estimated $5 million would be devoted to the radiation processed food program during the 5-year period, fiscal year 1960 to fiscal year 1964. However, budget figures were presented only for fiscal year 1960 and fiscal year 1961. We would, therefore, be interested in learning of your estimated budget for each of the following 3 years.

Thank you for your assistance.

Sincerely yours,

JAMES T. RAMEY, *Executive Director.*

ATOMIC ENERGY COMMISSION,
Washington, D.C., April 30, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. RAMEY: The following additional information of the Commission's radiation processed foods program is submitted in response to your April 11, 1960, letter. The questions are answered in the order in which they were presented.

1. Completion of construction of the Brookhaven National Laboratory High Intensity Development Laboratory is scheduled for midsummer, 1961. Installation of the cobalt 60 radiation source, test operation of the facility, and experimentation to establish the radiation source characteristics will require an additional 12 months. Therefore, it is not expected that the facility will be available for radiation studies on products such as food much before August 1962.

2. To date Brookhaven National Laboratory has contributed heavily to technical knowledge on safe, efficient use of high-intensity radiation sources, including the design of large-scale irradiation facilities. This basic radiation engineering research contributes to the total radiation processing field including food. The High Intensity Radiation Development Laboratory to be constructed at Brookhaven is specifically designed to permit research and development on processing parameters important in many radiation processing applications, including food.

Brookhaven will normally provide for the specific irradiator needs of the Commission's radiation processed foods program, including contracting for the design and construction and test operation of the irradiators prior to use by research groups.

It is expected further that Brookhaven National Laboratory will carry out some basic research in the field of microbiology as related to radiation processing of food. This type of research program is consistent with Brookhaven's scientific interests.

It is not planned currently, however, that Brookhaven will be responsible for the major research work to establish the quality, wholesomeness, or safety of low-dose radiation processed foods.

Brookhaven does not have either the specific technical capability in food technology or sufficient supporting facilities such as food preparation and research laboratories. It is our purpose to draw actively on the scientific competence and experience in food technology which exists within universities and private food research laboratories. We also plan to carry out cooperative research projects with the Departments of Agriculture and Interior to utilize their special technical resources in this field.

3. The Brookhaven National Laboratory is geographically located so that food products could be transported by air under refrigeration for limited experimental studies on radiation processing, if necessary. However, since radiation processing of foods as quickly as possible after harvest appears to be a limiting factor in the success of the low-dose technology, Brookhaven does not seem to offer the most desirable location for conduct of major food research projects on fish and fruits.

4. During the Commission's testimony at the March 31 hearings, it was stated that two laboratory research irradiators would be provided under the food program approved by the Commission for fiscal years 1960 and 1961. These irradiators will be capable of processing a few tens of pounds of food per hour with doses up to 1 million r. a. d. This quantity of food is adequate for carrying out basic research on food chemistry and changes in food quality such as color, taste, and odor.

To support the long-term animal feeding tests in the wholesomeness and safety program will require quantities of food in excess of the capability of the currently planned laboratory research irradiators. The full scope of the Commission's food research program will be mapped out the next few months, including specific identification of irradiator needs to support the program. As quickly as we firmly establish irradiator requirements, including those to support the

wholesomeness program, we will initiate design studies for these irradiators. If our overall progress in the food program during the early months is sufficiently good to permit initiation of the long term animal feeding tests in the wholesomeness and safety program during the latter part of fiscal year 1961, then we will make positive efforts to provide needed irradiation facilities for supplying the radiation processed foods for wholesomeness research.

5. It is planned that the first laboratory research irradiator will be completed and available for use by July or August of this year. We would expect to contract for design and construction of a second laboratory research irradiator shortly after the new fiscal year and have it completed and in use by the end of this calendar year.

We are now studying actively the specific locations for placement of the two laboratory research irradiators. It is our tentative planning to locate one research irradiator on the east coast for the study of fish. The second research irradiator may be used to support research on fruits and vegetables and be placed on the west coast. As quickly as we make a final determination on location and use of the two laboratory research irradiators, we shall inform the Joint Committee.

6. It is our purpose to keep the Joint Committee currently informed of progress of the Commission's radiation processed foods program and in line of your request, we shall specifically inform you as requirements for additional radiation facilities may be developed.

7. While Commission testimony has indicated that an estimated $5 million may be devoted to the radiation processed food program during the 5-year period, fiscal year 1960–fiscal year 1964, the Commission has not given specific consideration to the annual budget levels beyond fiscal year 1961. The levels by year beyond fiscal year 1961 will depend upon the technical progress in the program and the annual budgetary reviews.

I trust that the foregoing adequately sets forth the desired information.

Sincerely yours,

A. R. LUEDECKE, *General Manager.*

STATEMENT OF H. HERBERT HUGHES, CHAIRMAN, INTERDEPARTMENTAL COMMITTEE ON RADIATION PRESERVATION OF FOOD

Representative PRICE. The next and final witness at this hearing will be Mr. H. Herbert Hughes of the Department of Commerce, who is the Chairman of the Interdepartmental Committee on Radiation Preservation of Food.

Mr. Hughes, will you come forward, please?

Mr. HUGHES. Yes, sir.

Representative PRICE. I want to compliment you and the Interdepartment Committee for the position they have taken in the program. We are very interested in the report made by the committee. I want to compliment you and the other members of the committee.[1]

[1] See report of ad hoc panel, Interdepartmental Committee on Radiation Preservation of Foods on "National Civilian Radiation Processed Foods Program," pt. 1, p. 133, January 14 and 15 hearings.

Mr. HUGHES. Thank you. I am H. Herbert Hughes, Deputy Administrator of the Business and Defense Services Administration of the U.S. Department of Commerce, and since early January of this year, that is for something less than 3 months, I have been serving as Chairman of the Interdepartmental Committee. We appreciate, sir, your including the Interdepartmental Committee in your program today, and we feel it is complimentary to us that you have done so. I have with me here on my right the Secretary of the Committee, John Weber, and also several technicians who have been working with the Committee. There may be questions that you may want to direct to them.

Let me say at the outset that I am not technically qualified in this field and the Department of Commerce interest, except for the Bureau of Standards, is solely one as liaison with industry. At such time as it is appropriate in our view to bring in industry and to try to generate industry interest in this program, we feel that we in the Department of Commerce will be able to contribute substantially to the ultimate objectives.

I mention the Department of Commerce Bureau of Standards where they do work on physical measurements, the development of techniques and the establishment of standards of physical measurement.

With your permission, sir, perhaps you might like a brief chronology of the ad hoc panel. It came into being before I was Chairman, and when Mr. H. B. McCoy, who was then Administrator of BDSA served as Chairman. It came into existence primarily because there was a feeling that perhaps with the reduction of work on the part of the Army which Mr. Morse has indicated may have been misinterpreted to some extent, there was a feeling that perhaps the program was lagging. Those who were then on the Committee felt that this should not happen.

Mr. McCoy called a meeting of the full Committee on November 24, and it was decided at that time to set up this ad hoc panel group.

Representative PRICE. Will you identify the membership of your Committee?

Mr. HUGHES. By agencies or by names of people?

Representative PRICE. I see you have quite a list. Will you supply the list for the record?

Mr. HUGHES. Yes, sir.

(The list referred to follows:)

Technical points of contact for the Interdepartmental Committee's radiation preservation of food program

Work phases	Department of State (code 182)	Department of Interior (code 183)	Department of Agriculture (code 111)	Department of Commerce (code 112)	Department of Health, Education, and Welfare (code 181)
I. Broad program stimulation and coordination.	Charles A. Sullivan, 4203. William A. Chapin,[1] 2372.	Arnie J. Suomela, 4678. Andrew W. Anderson,[1] 4993.	Ervin L. Peterson, 3306. George W. Irving, Jr.,[1] 5134.	H. Herbert Hughes, 4506. Jacob M. Schaffer,[1] 4365.	George P. Larrick,[1] 5140.
A. Chairmanship of Interdepartmental Committee.				H. Herbert Hughes, 4506.	
II. Research and development:					
A. Source of radiation:					
1. Source development			Merrill E. Jefferson,[2] 345.	E. Joseph Hand, 543.	
2. Radiation services				do.	
3. Dosimetry measurement standards.			Merrill E. Jefferson,[2] 345.	H. W. Koch,[6] 7451.	
4. Health physics			do.[3]	do.[6]	James G. Terrill, Jr.,[3] 5105.
B. Wholesomeness:					
1. Feeding studies		John A. Holston, 4745.	John R. Matchett, 6961.		Arnold J. Lehman,[7] 4708. Do.[3 7]
2. Official clearance			Robert K. Somers, 2785.	H. W. Koch,[6] 7451.	William C. Miller, Jr., 3508.
3. Inspection methodologies and specifications.		John A. Holston, 4745.	do.[3]	do.[6]	Arnold J. Lehman,[7] 4708. William C. Miller, Jr., 3508.
C. Commodity development:					
1. Insect deinfestation (grains, cereal products, fruits, livestock).			Edward F. Knipling,[2 3] 377. Lyman S. Henderson,[2] 302.		Kenton L. Harris,[7] 5424.
2. Parasite control (foodborne diseases).			Edward F. Knipling,[2] 377. Lyman S. Henderson,[2] 302.		Do.[3 7]
3. Extension of storage of fruits and vegetables.			John R. Matchett,[3] 6961. Wilbur T. Pentzer, 4771.		
4. Pasteurization and sterilization of meats.		John A. Holston, 4745.	John R. Matchett,[3] 6961.		William C. Miller, Jr., 3508.
5. Pasteurization and sterilization of seafoods.		do.[3]			Do.
6. Packaging materials		do.	Robert E. Hardenburg,[2] 404.	Charles A. Lewis, 3962. F. W. Reinhardt,[5] 328.	
D. Process equipment development:					
1. Equipment		do.	John R. Matchett, 6961.		
2. Measurement		do.	do.	Nathan D. Golden,[3] 4378. Thomas W. Delahanty, 2776.	
E. Pilot plant construction				E. Joseph Hand, 543.	
F. Pilot plant operation				do.	
III. Phasing into free economy:					
A. Industrial education		Donald Y. Aske, 2151.	John R. Matchett, 6961.	John C. Green,[3] 2143.	

III. Phasing into free economy:					
A. Industrial education	Donald Y. Aska, 2151.	John R. Matchett, 6961.	John C. Green,[3] 2143. W. P. Richardson,[6] 7381.	Earl M. Bowler, 7744.	
B. Economic and market analysis	do.	Robert B. Reese, 3056.	Harry W. Ketchum,[3] 4481. Louis J. Paradiso, 2507.		
C. Government financial encouragement.	H. E. Crowther, 4386.	George W. Irving, Jr., 5134.	E. Joseph Hand,[3] 543.		
IV. International relations	Donald E. Larimore,[3] 4652.	Gustave Burmeister, 2705.	Herbert N. Blackman, 3217. Lauristan S. Taylor,[6] 511.		

Work phases	Department of the Army (code 11)	The Atomic Energy Commission (code 119)	Small Business Administration (code 128)	International Cooperation Administration (code 113)
I. Broad program stimulation and coordination	Richard S. Morse, 56153. R. G. H. Siu,[1] 74862.	A. Tammaro, 5401. Paul C. Aebersold,[1] 3188.	Donald A. Hipkins, 5403. James Salisbury, Jr.,[1] 5525.	Herman Kleine, 2553. James C. Meem,[1] 3557.
A. Chairmanship of Interdepartmental Committee.				
II. Research and development:				
A. Source of radiation:				
1. Source development	Robert M. Rodden,[3 4] 4553.	Joseph E. Machurek,[3] 3070.	G. Wilbur Seymour, 6348.	
2. Radiation services	David H. Rest,[3 5] Q.M.F. & C.I.	do.[3]		
3. Dosimetry measurement standards	Joseph Berg,[5] Q.M.F. & C.I.	Richard W. Johnston, 5355.	Ernest W. Reisner, 5408.	
4. Health physics	Robert M. Rodden,[4] 4553.	G. Victor Beard, 3693.		Eugene P. Campbell, 3032.
B. Wholesomeness:				
1. Feeding studies	Laurence M. Hursh, 65472.	Richard E. Benson, 3681. James L. Liverman, 3785.		Katherine Holtzclaw, 3668.
2. Official clearance	do.	Richard E. Benson, 3681. James L. Liverman, 3785.		
3. Inspection methodologies and specifications.	Charles W. Gallehon, 65502.	Richard E. Benson, 3681. James L. Liverman, 3785.	Ernest W. Reisner, 5408.	
C. Commodity development:				
1. Insect deinfestation (grains, cereal products, fruits, livestock).	David H. Rest,[5] Q.M.F. & C.I.	E. Eugene Fowler, 3149.	Deck Reynolds, 5186.	Paul E. Johnson, 2597.
2. Parasite control (foodborne diseases)	do.[5]	do.	do.	Eugene P. Campbell, 3032. Paul E. Johnson, 2597.
3. Extension of storage of fruits and vegetables.	do.[5]	do.	do.	Paul E. Johnson, 2597.
4. Pasteurization and sterilization of meats.	do.[5]	do.	do.	Do.
5. Pasteurization and sterilization of seafoods.	do.[5]	do.	do.	Do.
6. Packaging materials	George E. Tripp,[3 5] Q.M.F. & C.I.	do.	George S. Hartman, 4909.	Do.
D. Process equipment development:				
1. Equipment	Olaf E. Stamberg, 74366.	Robert M. Rodden, 4553.	Deck Reynolds, 5186.	
2. Measurement	do.	do.	do.	
E. Pilot plant construction	do.[3]	do.	Harold S. Lang, 5036.	
F. Pilot plant operation	do.[3]	do.	do.	

See footnotes at end of table, p. 752.

Technical points of contact for the Interdepartmental Committee's radiation preservation of food program—Continued

Work phases	Department of the Army (code 11)	The Atomic Energy Commission (code 119)	Small Business Administration (code 128)	International Cooperation Administration (code 113)
III. Phasing into free economy:				
A. Industrial education	David H. Rest,[1] Q.M.F. & C.I.	Paul C. Aebersold, 3188	Wendell O. Metcalf, 5400	
B. Economic and market analysis	Olaf E. Stamberg, 74366	do	Wilford L. White, 5197	
C. Government financial encouragement	William B. Levin, 78984	do	Robert C. Maxwell, 5855	
IV. International relations	do	Edward E. Sinclair, 5353		James C. Meem, 3557.

[1] Alternate member, general point of contact.
[2] Beltsville, Md., Webster 5-4620.
[3] Phase group leader.
[4] Code 119 (office located in AEC).
[5] Quartermaster Food and Container Institute (Chicago), Lafayette 3-5500.
[6] Bureau of Standards, code 154.
[7] Code 111 (office located in USDA).
Revised Jan. 21, 1960.

In addition to members, we have alternates, and we have some very active and aggressive technicians. It is quite a large group of people when we meet.

At the November 24 meeting, the Committee decided to set up this ad hoc panel under the chairmanship of Dr. Paul Aebersold of the AEC. The panel went to work right after the first of the year, and brought in a draft report to the meeting of the full Committee on February 12.

At that time the Committee members felt that the panel had done an excellent job. They felt that the report of the panel needed to be brought to the attention of the heads of the agencies represented in the interdepartmental group, and that was done. By mid-March, we had reactions back from all the agencies, and we had another meeting on March 21 at which time we felt that the job of the ad hoc panel was well done, because the reactions that came back from the agencies indicated that action was being taken by the AEC, and you have just heard detailed testimony on that. Some of the agencies who were vitally interested in this field said that while they approved the report of the panel, they reserved their right to continue to work in the field where it was obviously in their scope of activity.

We have submitted to your staff, I think, all pertinent documents relating to the ad hoc panel. You have a copy of the report itself. You have copies of the letters from the agencies who reviewed the report. You have a copy of the pertinent notes on the agenda of our last meeting on March 21. (See app. 1, p. 761.) I would like to call attention to one paragraph and read it into the record—that the ad hoc panel report recommends that the Interdepartmental Committee make recommendations concerning policies and budgets for the national civilian program. But the Committee feels that this is not within the scope and purpose of the Interdepartmental Committee. So that section which I think starts on page 19 of the ad hoc panel report was not accepted as written, because the Committeee does not feel that is within the function of the Committee as it is constituted.

I found in the short while I have been associated with the Committee that it is a very refreshing experience. The Committee has no official status. It was pretty much self-generated, set up originally by the Department of Defense and the Army, and it is self-perpetuating. We do not tie back to any legislative or executive directive, or even request. It is a very interesting forum. It is a group of people thoroughly knowledgeable in this field, and we think it provides an extremely useful medium for those agencies who are directly interested to get together to compare notes, and more importantly, perhaps, to give other agencies who have a vital interest in the ultimate results but not in the technical content, the technical carrying out of the program, that gives them an opportunity, too, to keep informed as to what is going on.

I would say that the main problem confronting our Committee right now is where do we go from here? One of our important objectives, of course, is to bring in appropriate liaison with private industry. We feel right at this moment, until the programs you have heard details of today are a little more underway, it is premature perhaps to make any formal approaches to industry. But I think all of us on the Committee, at every opportunity, do discuss with people they

know in industry what is going on and at an appropriate time we will take up within the Committee more specific means as to how we might in our small way effect a more direct liaison with industry.

That is all I want to comment on at the moment, but I, and especially my technical associates, will be very pleased to answer any questions you may have.

Representative VAN ZANDT. Have you reviewed the Army program as it was presented to us this morning?

Mr. HUGHES. The Committee as a committee?

Representative VAN ZANDT. Yes.

Mr. HUGHES. No, sir.

Representative VAN ZANDT. Have you personally?

Mr. HUGHES. I have read what I have seen and I heard the testimony this morning. But it would be presumptuous of me to make any particular comments on it because I am not technically competent in that field.

Representative VAN ZANDT. Do you think it would be a good idea for the Committee to take a look at the Army program?

Mr. HUGHES. I am not sure, sir, that is within the prerogatives of our Committee, except perhaps in a very informal way. I think possibly we might get together and informally discuss it. I am quite positive that the Atomic Energy Commission and others interested are doing that continuously with the Army. But we have no review function, as I see the purpose of our Committee, to criticize or comment technically on the programs of any agency.

Representative VAN ZANDT. That is all, Mr. Chairman.

Representative PRICE. Mr. Bates.

Representative BATES. I would like to ask the Bureau of Commercial Fisheries a question in respect to the net advantage of the United States on irradiation. The fresh fish market is limited. Once we irradiate food, then it means a lot of the imported food will be irradiated.

Mr. CROWTHER. That is half right.

Representative BATES. Make it all right.

Representative PRICE. Will you come up, sir, and identify yourself for the reporter?

Mr. CROWTHER. My name is H. E. Crowther, Chief of the Division of Industrial Research for the Bureau of Commercial Fisheries. As I received your question, Mr. Bates, you asked if the imported fish could not receive the same benefits as our domestic fish. It could in some extent. However, I think irradiation would be quite a boon to our domestic industry because the pasteurization method that is used for irradiation of fish only gives a relatively short extension of life. For example, if we can extend it up to 10 days, it would be quite an item as far as our own industry is concerned.

Representative BATES. Extend it 10 days beyond what we have today?

Mr. CROWTHER. Beyond what we have now. That would still permit importation of fillets into your area, for example, from Canada. However, it would exclude shipments from long distances such as Iceland, Norway, and other countries.

Representative BATES. In respect to Canada?

Mr. CROWTHER. Canada would be able to import irradiated fillets.

Representative BATES. For the Canadian fisheries to get into the center of the country here, from the point of view of time, it would be about the same as it would be for the domestic production.

Mr. CROWTHER. Possibly 2 days more.

Representative BATES. Two days more for Canada?

Mr. CROWTHER. I would say so.

Representative BATES. In one case you have a trawler coming back which takes a lot longer than it does one who lands at Halifax, and then comes down by motor. So there may be no difference at all.

Mr. CROWTHER. In the way we visualize it only fillets could be irradiated, and not the whole fish. That would mean that they would have to be processed in Canada and then shipped.

Representative BATES. Only the fillets could be irradiated?

Mr. CROWTHER. That would be the only feasible thing to irradiate as far as ground fish are concerned, such as cod, haddock, ocean perch.

Representative BATES. Why would that be so?

Mr. CROWTHER. As you mentioned before, it would be a real problem of carrying out this process aboard vessels. So you would have to have a shore installation. Your demand for fishery products of the ground fish variety are in the fillet form. So it would not pay to ship whole cod and haddock to your inland markets. Therefore, your irradiation would best be done on fillets.

Representative BATES. That is because then of the ready pack. That is a marketing proposition, rather than a feasibility.

Mr. CROWTHER. And the weight involved in the shipments. It is much less costly to ship fillets than it would be to ship the whole fish. The market itself is conditioned to the purchase of fillets, rather than fish in the round form.

Representative BATES. That depends how far removed one is from the seacoast.

Mr. CROWTHER. Your Midwest is certainly conditioned to that, Mr. Bates.

Representative BATES. We buy whole fish in my area, not fillets.

Mr. CROWTHER. It is only in your limited area around the seacoasts that that is true. It is a very limited amount of the whole fish that is shipped for more than 50 miles. From that point on, it is the fillets. The big marketing area is in the Midwest, and practically only fillets go to that area.

Representative BATES. That is frozen today.

Mr. CROWTHER. That is right.

Representative BATES. You don't think there is a market in the Middle West for whole fish irradiated?

Mr. CROWTHER. No, sir; I don't. The buying habits of the housewife are such now that they are getting away almost entirely from having to handle the whole fish and to dress it. Only real fisheaters will put up with the inconvenience of using the whole fish.

Representative BATES. As a matter of fact, you never really eat fish unless you have fresh fish. You know that.

Mr. CROWTHER. I would agree.

Representative BATES. In your judgment we won't have whole fish irradiated.

Mr. CROWTHER. That is my opinion, sir.

Representative BATES. Maybe we can get Canada to do a little advertising for us for a change. Is the consumption still about 10½ pounds per person in the United States?

Mr. CROWTHER. It is 10.4 for this year.

Representative BATES. It has been about that same figure for how many years, 10, 20?

Mr. CROWTHER. I would say at least 10. It has fluctuated a little.

Representative BATES. It fluctuated during the war, and it fluctuates when the price of beef goes up. Generally it has been about 10.5.

Mr. CROWTHER. That is right. It has fluctuated between 10 and 11, and has not gotten out of that range.

Representative PRICE. I notice that the Fish and Wildlife Service in commenting on the budgeted program for fiscal years 1960 to 1965, suggested a centralization in and the handling by a single operating agency to be designated by the Interdepartmental Committee for Irradiation Preservation of Food of the budgeting problems for this fish irradiation program. The testimony given here today indicates that there is no central agency now to provide program direction for the civilian and military food irradiation program. In the setup of the reactor program, the civilian and military reactor programs, you do have central direction. For instance, in the military, even though they may be interested in reactor development, they are interested through an Army Reactors Branch. Wouldn't it be advisable to have some central direction to this overall program of food irradiation? Would you comment on that, Mr. Hughes?

Mr. HUGHES. I believe, sir, that you and your full Committee are better judges of that.

Representative BATES. We have to look for a little advice sometimes. Sometimes we get a little lost in the conflicting testimony that we get on these matters.

Mr. HUGHES. Certainly in our Committee, sir, we have no authority whatsoever to even think about undertaking any such task. I would think if you really seriously wanted to explore that, and wanted the advice of an interdepartmental group, that you would call on the heads of the interdepartmental agencies involved to give you that advice because you are getting into a realm now of policy which is certainly beyond my position in the Department of Commerce.

Representative BATES. The Fish and Wildlife Service people took that position because they stated that otherwise the failure of a single agency to obtain approval for its program might well cripple the entire program and render ineffective efforts by other cooperating agencies. They thought that they could work better through a central agency in handling this program. Now they would have to go in two directions, wouldn't they?

Mr. HUGHES. I will say, sir, if you want my personal opinion, that I have no views that I could give you that would be helpful. I don't feel technically competent to express views in this area.

Representative PRICE. Are there any other questions? If not, thank you very much.

Mr. HUGHES. Thank you, sir.

Representative PRICE. Without objection, the copies of the documents which were received from the Interdepartmental Committee will be included in the record. (See app. 1, p. 761.)

The committee will stand adjourned.

(Whereupon, at 12:45 p.m., Thursday, March 31, 1960, the subcommittee adjourned.)

(Correspondence, in connection with the Interdepartmental Committee on Radiation Preservation of Food, follows:)

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., April 14, 1960.

Mr. JOHN CONWAY,
Assistant Director, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. CONWAY: I am forwarding to you a copy of a letter dated March 1, 1960, from Col. L. M. Hursh, Office of the Surgeon General, to Dr. Donald L. McKernan, Bureau of Commercial Fisheries, which presents a summary of data collected in animal feeding studies with radiation processed marine products.

These data are directly related to the considerations by the ad hoc panel in determining that immediate attention under the low dose radiation processing program should be directed to fish.

You may find this information sufficiently interesting to include as part of the record of the Joint Committee's hearings on radiation preservation of foods.

Sincerely yours,

PAUL C. AEBERSOLD,
Chairman, Ad Hoc Panel, Interdepartmental Committee on Radiation Preservation of Food.

HEADQUARTERS,
U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND,
OFFICE OF THE SURGEON GENERAL,
Washington, D.C., March 1, 1960.

Dr. DONALD L. MCKERNAN,
Director, U.S. Department of the Interior, Fish and Wildlife Service,
Bureau of Commercial Fisheries,
Washington, D.C.

DEAR MR. MCKERNAN: Inclosed is a brief summary of irradiated food data as of February 1, 1960. Items 6, 7, and 8 will perhaps be of special interest to you. I have asked Colonel Plough of the USAMR and NL in Denver to send you the investigator's individual reports. Their conclusions are as follows:

CODFISH

Dr. Salmon

Rats

No essential differences were noted in growth rate, food consumption, and food efficiency, hematology, breeding performance, or longevity of rats that received 35 percent of their diet in the form of irradiated codfish as compared with animals that received nonirradiated foods.

Dogs

Based on 2-year feeding study, it appears that the dog will thrive as well on irradiated codfish as on foods that are nonirradiated (35-percent level).

SHRIMP

Dr. Phillips

Rats

The long-term feeding of irradiated shrimp at 35 percent diet solids was terminated at 104 weeks. No marked differences in longevity between control and irradiated groups were indicated, however, statistical analysis of the data remains to be performed. Histopathological examination of the tissues are in progress.

Growth response of third generation rats were significantly different to the three levels of irradiated shrimp. Female sterility was somewhat higher in the irradiated groups.

Dr. Engel

Dogs

Based on weight gain, gestation, lactation, and hematologic measurements, there was no evidence that irradiated shrimp were different in any way from nonirradiated shrimp fed in the fresh frozen state in a study in which 35 percent of the dry matter of the ration was composed of shrimp.

TUNA

Dr. Paynter

Rats

With exception of some very minor statistical differences there seemed to be no major differences among the various dietary groups.

Dr. McKay

Dogs

No deviations from normal were found in dogs eating 35 percent tuna.

I am sure you realize the above comments are all tentative and may require revision when the statistical analysis and histopathology are complete.

If you wish greater detail than is given in their reports which you will receive soon, I'm sure the investigator would be glad to discuss his project with you.

It is not possible for us to predict the probability of early clearance of fish and shellfish at this time.

Sincerely,

L. M. HURSH,
Colonel, MC, Chief, Medical Research Branch.

(Department of Commerce, March 28, 1960, and Department of the Army, March 29, 1960, press releases on the national food irradiation program follow:)

MARCH 28, 1960.

GOVERNMENT INCREASES RESEARCH ON RADIATION PROCESSING OF FOODS

Through the stimulus of the Interdepartmental Committee on Radiation Preservation of Foods, definite steps are now being taken to carry forward a national program of research and development on radiation processing of food. This important phase of the President's atoms-for-peace program was announced today by H. Herbert Hughes, Deputy Administrator of the Business and Defense Services Administration, U.S. Department of Commerce, who is Chairman of the nine-agency Committee, following a meeting of the Committee held on March 21, 1960.

These steps include the following:

The Atomic Energy Commission has established a program of research and development on low-dose radiation processing of perishable foods to extend shelf life. During the next 5 years the Atomic Energy Commission expects to spend approximately $5 million on this project. During fiscal years 1960 and 1961, $115,000 and $500,000, respectively, are being devoted to the program. Under the Atomic Energy Commission program emphasis will be placed on basic studies in food chemistry, microbiology, wholesomeness testing, preservation factors of shelf life extension and radiation processing technology.

The Department of the Army has approved a revised Army food irradiation program. Over a 6-year period, the Army research program will cost an estimated $5 million. It also proposes to construct a radiation food research facility to cost about $1,800,000. This facility will consist of a megacurie cobalt 60 gamma irradiator, variable voltage linear electron accelerator, and associated facilities with emphasis on high-dose treatment of foods.

The Departments of Agriculture, Interior, and Commerce have conducted research and development in their respective areas and indicate they plan to continue their individual programs in cooperation with the Army and the Atomic Energy Commission.

To avoid duplication of effort, close and direct cooperation and interchange of information among all the member agencies are in effect.

Research on the use of radiation for processing food must take into account the provisions of the several food regulatory acts, such as those administered by the Department of Health, Education, and Welfare, and the Department of Agriculture. The wholesomeness and safety of radiation-processed food must therefore be established to the satisfaction of these agencies.

Agencies represented on the Committee are: Departments of State, Interior, Agriculture, Commerce, Health, Education, and Welfare, Army, Atomic Energy Commission, Small Business Administration, and International Cooperation Administration.

Mr. Hughes indicates that, as the national research and development program on radiation processing of food progresses, the Interdepartmental Committee through its member agencies will encourage commercial adoption of this technology.

MARCH 29, 1960.

ARMY PLANS NEW PROGRAM TO SPEED IRRADIATED FOOD RESEARCH

A revised 6-year, $5 million program to accelerate research on specific irradiated foods for military use was announced today by the Department of the Army.

The new program, developed at the direction of Richard S. Morse, Army Director of Research and Development, will concentrate on food items considered to be of prime military importance and which have shown promise as a result of Army food irradiation research activities conducted over the past 5 years.

The revised program will continue to be administered by the Army Quartermaster General.

The new Army program was developed following the Army's decision, announced last October, to suspend construction of a proposed $7.5 million U.S. Army Ionizing Radiation Center at the Army's Sharpe General Depot, Stockton, Calif., pending further laboratory studies to determine the feasibility of radiation as a practical means of food preservation.

In lieu of this full-scale pilot production plant, the Army now plans to construct a research facility geared directly to the needs of the revised program. The facility will consist of a million curie cobalt 60 irradiator, and a variable energy electron source. Much of the planning and equipment developed for the original pilot production plant will be adapted for use in the new research facility.

The location of the new research facility has not, as yet, been determined. According to present plans, it will be operational in about 2 years. The facility will be made available for use of other agencies working in this field.

Under the new program, the Quartermaster Corps will concentrate primarily upon completing research involving sterilized pork, beef, and chicken.

The Quartermaster General will be responsible for formulating the new irradiated food items into suitable ration components for field use by the Army, and for adapting them to specialized requirements of the other services. The Quartermaster Corps also will develop engineering data for eventual use by commercial processors.

The Army Surgeon General will continue to be responsible for conducting wholesomeness studies of irradiated food in collaboration with the Food and Drug Administration. Results of these studies will be available to other interested agencies.

At the time he suspended construction of the originally planned Army Ionizing Radiation Center last October, Mr. Morse pointed out that certain physiological problems resulting from feeding irradiated foods to laboratory animals had not been resolved. It is well known that the high doses of radiation required to achieve sterilization cause chemical changes in the protein, fat, and carbohydrate molecules of the food. The extensive wholesomeness studies involving 250,000 mice, rats, monkeys, dogs, and chickens were designed to determine if any of these chemical alterations were harmful. The vast majority of the experimental data now available demonstrates no harmful effects. However, some problems related to irradiated meat have been encountered and will require

continuing fundamental research in food chemistry. The radiation research facility will provide for the rigidly controlled exposures of the food essential to this research.

Under the revised program, the Army will continue to study economic and logistic advantages of using irradiated foods in the military supply system.

The Army program will concentrate on total sterilization to preserve food for long periods of time. This is the aspect of irradiated food of greatest interest to the military. The Army program will be closely coordinated with a civilian research program being developed by the Atomic Energy Commission and with the Interdepartmental Committee on Radiation Preservation of Food. This program will concentrate on low-dose radiation processing of perishable food to extend shelf life.

APPENDIXES

APPENDIX 1

CORRESPONDENCE BETWEEN VARIOUS DEPARTMENTS AND THE INTERDEPARTMENTAL COMMITTEE ON RADIATION PRESERVATION OF FOOD CONCERNING THE PROPOSED INVESTIGATION ENTITLED "A NATIONAL CIVILIAN RADIATION PROCESSED FOODS PROGRAM"

U.S. DEPARTMENT OF COMMERCE,
INTERDEPARTMENTAL COMMITTEE ON RADIATION PRESERVATION OF FOOD,
Washington D.C., March 24, 1960.

Hon. MELVIN PRICE,
Chairman, Subcommittee on Research and Development, Joint Committee on Atomic Energy, House of Representatives, Washington, D.C.

DEAR MR. PRICE: At the request of your executive director, Mr. James T. Ramey, I enclose a copy of the following Interdepartmental Committee on Radiation Preservation of Foods documents:

(1) Notes on agenda of Committee meeting held March 21, 1960.

(2) A copy of comments relative to the Committee's ad hoc report from all agency heads or representatives that hold membership on the Committee. (You already have the ad hoc panel report entitled "A National Civilian Radiation Processed Foods Program.")

If the Committee or its members can be of further service to you please call on us.

Sincerely yours,

H. HERBERT HUGHES, *Chairman.*

INTERDEPARTMENTAL COMMITTEE ON RADIATION PRESERVATION OF FOOD

NOTES ON AGENDA

March 21, 1960

(1) Following the last meeting of the Interdepartmental Committee, the report of the ad hoc panel on "A National Civilian Radiation Processed Foods Program," as amended at the meeting, was referred to member agencies for comment. Response has been received from all member agencies.

(2) The Atomic Energy Commission has advised that it has established a program of research and development on low dose radiation processing of foods to extend shelf life. During the next 5 years the Atomic Energy Commission anticipates devoting approximately $5 million to this project. During fiscal year 1960 and 1961, funds in the amount of $115,000 and $500,000, respectively, are being made available for the program. Emphasis under the Atomic Energy Commission program will be placed on basic studies in food chemistry, microbiology, wholesomeness testing, preservation factors of shelf life extension, and radiation-processed technology. The Atomic Energy Commission believes its program is consistent with the technical objectives set forth in the ad hoc panel report.

(3) The Department of the Army advises it has approved a revised Army food irradiation program. Over a 6-year period, the Army research program will incur an estimated cost of $5 million. It also proposes to construct a radiation food facility to cost an estimated $1.8 million. This facility will consist of a megacurie cobalt 60 gamma irradiator, variable voltage linear electron accelerator, and associated facilities.

(4) The other agencies having representation on this Committee and who have conducted research and development in their respective areas have indicated they too will continue their individual programs.

(5) In view of the positive steps having been taken, through the stimulus of the Interdepartmental Committee to carry forward research and development on both high and low dose radiation processing of food, it is timely to review the present and future role of the Committee.

(6) Not all may be familiar with the history of this Committee. Several years ago when the Department of the Army was supporting the major Government activities in radiation processing of foods the Committee was established at the request of the Secretary of Defense. The Director of Research and Development for the Department of the Army was designated as its first Chairman. In August 1958, the chairmanship was transferred from the Department of the Army to the Department of Commerce. The purpose of the Committee is to promote early commercial realization of radiation-processed foods and thus maintain world leadership in this important segment of the Nation's atoms for peace effort. The functions of the Committee are—

(*a*) To provide motivation and broad guidance for the program.

(*b*) To achieve a high level of participation by Government agencies and industry.

(*c*) To effect a transition of program responsibility from the military to other Government agencies and to industry as rapidly as possible.

(7) It is apparent that the Interdepartmental Committee has been successful in providing broad guidance in this program; achieving active participation by all interested Government agencies and in stimulating increased efforts toward a civilian program.

(8) The ad hoc panel report recommends that the Interdepartmental Committee make recommendations concerning policies and budgets for the national civilian program. This is not within the scope and purpose of the Interdepartmental Committee.

(9) To avoid duplication of effort close and direct cooperation and interchange of information among the staff of all member agencies is in effect.

(10) It appears the next major phase in this program will be the need to attract private industry to assume greater responsibilities in this area in light of research and development advances resulting from the Government program. As the program progresses the Interdepartmental Committee, through its member agencies, should bring to bear their full resources to commercialize radiation processing of foods.

DEPARTMENT OF THE INTERIOR,
FISH AND WILDLIFE SERVICE,
BUREAU OF COMMERCIAL FISHERIES,
Washington, D.C., March 18, 1960.

Mr. H. HERBERT HUGHES,
Interdepartmental Committee on Radiation Preservation of Food,
U.S. Department of Commerce, Washington, D.C.

DEAR MR. HUGHES: Inasmuch as the Bureau of Commercial Fisheries is directly concerned with preservation and processing of fishery products, Secretary Seaton has requested that I reply to your letter of February 17, 1960, concerning the ad hoc working group's report. The Bureau's comments on the report are listed below. We wish to assure the Committee of the complete support of the Bureau in the proposed investigation, entitled, "A National Civilian Radiation Processed Foods Program."

Our experienced fishery researchers feel that successful development of low-level radiation processing of fish and shellfish may lead to the rebirth of the fresh (chilled) fish industry. The extension of the shelf life of fresh fish by from 5 to 8 days would permit marketing of unfrozen fish all over the country. At present, fresh fish and shellfish are commonly enjoyed only by consumers living in areas immediately adjacent to our fishing ports. We are especially pleased since rebirth of this phase of the fishing industry will benefit directly our domestic fishermen and processors. As you know, they are suffering exceedingly from the inroads made by imports on their frozen fish markets. It is our considered opinion that a potentially large market for fresh fish awaits successful development of techniques for low-level radiation preservation of foods.

In general, we are in full agreement with the recommendations embodied in the report. Owing to this Department's Congress-assigned responsibilities to protect and foster the growth of the fishing industry, we have listed below certain basic operational policy requirements which must govern our agreement

to and participation in the proposed new program. We are certain that such requirements will be endorsed by other cooperating agencies and request that the Committee consider them for adoption as general operating guidelines.

1. No news releases or reports on the fishing industry aspects of the proposed program may be made without prior clearance by the Director of the Bureau of Commercial Fisheries.

2. The U.S Fish and Wildlife Service will require that all proposals for radiation processed foods research on fishery products must be approved by its staff representatives in the Bureau of Commercial Fisheries in order that such research may be integrated into its own program to avoid duplication of effort.

In addition to the basic policy requirements listed above, we have several general recommendations which we feel will materially hasten progress on the proposed program. We request that the Committee consider these recommendations also for inclusion in the report.

1. It is proposed that all budgeting for the program in fiscal years 1962, 1963, 1964, and 1965 be centralized in and handled by a single operating agency to be designated by the Interdepartmental Committee for Radiation Preservation of Food. Otherwise the failure of a single agency to obtain approval for its program might well cripple the entire program and render ineffective efforts by othe cooperating agencies. Participating agencies will develop and submit their programs to the operating agency for budget processing.

2. The marine products irradiator should be budgeted for construction in fiscal year 1962. It would appear undesirable to delay the proposed civilian program pending decision by the Army to construct the National Center This is particularly true when the selected site may be such as to preclude its effective use in the civilian low-level radiation processing program.

3. Costs of replenishing or replacing radiation sources should be assumed by the Atomic Energy Commission as a normal adjunct to its rightful function of planning and constructing the irradiators.

4. The following species of fish and shellfish should be included in the study: tuna, shrimp, crab, haddock, and flounder. These represent (1) all geographical areas of fishing, (2) the species which can most easily adjust in price to meet any possible added costs for preservation, (3) the most popular and accepted fishes and shellfish, (4) high-fat and low-fat fishes, (5) surface and ground fish species, and (6) both round and flat fish species. Army wholesomeness studies are nearly complete for tuna and shrimp. Cod, a species very closely related to haddock, are also being studied in the Army wholesomeness tests. We are optimistic that clearances for shrimp and cod will be extended by the Food and Drug Administration to cover crabmeat and haddock.

Sincerely yours,

DONALD L. MCKERNAN, *Director.*

DEPARTMENT OF AGRICULTURE,
Washington, D C., March 11, 1960.

Mr. H. HERBERT HUGHES,
Chairman, Interdepartmental Committee on Radiation Preservation of Foods, Department of Commerce, Washington, D.C.

DEAR MR. HUGHES: This is in response to your request of February 17 for our comments concerning the report of the Interdepartmental Committee's ad hoc working group entitled "A National Civilian Radiation Processed Foods Program."

The Department's principal comment concerns the proposal that a single agency, in this instance the Atomic Energy Commission, function as the operating agency for administration of the program. We believe the programs of the individual agencies in this field should continue as individual programs and that the Interdepartmental Committee should continue to exercise a coordinating function.

Each of the agencies represented on the Interdepartmental Committee has unique responsibilities and seeks specific objectives. Radiation is currently being explored by each agency as a means for achieving some of them. Agriculture, for example, has responsibility for improved production, handling and processing of agricultural commodities and accordingly seeks practical means for improving the efficiency of food production, processing, and marketing. The Department of Interior has similar responsibilities and objectives with respect

to marine products. The Department of Defense has responsibility for assuring that food supplies meet the specific requirements of the military and strives for improvement in all aspects of this field. These agency goals are sufficently specialized that no one agency would be expected to assume all of them, but are closely enough related that the common meeting ground afforded by the Interdepartmental Committee helps each agency to make its own evaluation and develop applications of radiation for achieving its own objectives. The Interdepartmental Committee was created to serve this purpose and can continue to serve it effectively.

The program proposed in the report will be a useful guide for the Interdepartmental Committee and its participating agencies and should be regarded as one to be attained or approached as agency programing and budgetary considerations permit.

The Department of Agriculture wants and expects to continue its investigations of the potentialities of radiation in the production, processing, and marketing of foods. The nature and level of our programs in this field will be determined by the likelihood of practical results and by our budgetary capacity to conduct such investigations along with research on other problems requiring attention. The Department will wish to continue to work closely with other members of the Interdepartmental Committee and to make maximum use of the specialized facilities that the Atomic Energy Commission or the Department of Defense, in the course of their own programs, can make available to the Department for its studies. The Department favors maintenance and operation of extensive radiation facilities by the Atomic Energy Commission, where expertness exists, with opportunity for other agencies to avail themselves of them as needed and as mutually agreeable, for studies in the food preservation field.

The following additional comments are offered with respect to the several sections of the report:

Part A: The Department believes part A of the report adequately reflects the current status of technology in the radiation processing of foods.

Part Z–I: We believe it is a logical immediate objective for all agencies to concentrate their research on a small number of selected food products which appear to promise early technical feasibility, and let appropriate studies of market acceptance and introduction into the economy follow any that are successful.

Part B–II: We agree generally with the statements made under subsections A through G with the exception of subsections B and E. Studies of wholesomeness and demonstration of public acceptance are secondary to demonstration of industrial feasibility and can well await more convincing evidence than now exists that there will be industrially feasible radiation processes for civilian food processing.

Part B–III: Under the alternative plan for program administration suggested above, the Interdepartmental Committee would assume many of the functions indicated for the "operating agency" under paragraph D.

Part B–IV: We agree with statements A, B, and C. We also agree with statements D, E, and F, but believe the studies suggested therein can be deferred pending indications of promise in the studies outlined in B and C.

Part B–V: We agree if judgment is used in administering "a policy of maximum cooperation with industry" so that cooperation is not confused with promotion, especially premature promotional activities. The Department of Agriculture believes that the present state of our knowledge with respect to the industrial potentialities of radiation for civilian food preservation calls for conservatism in our representations to the food industry.

Part B–VI: The projection of facility needs appears reasonable.

We are glad to have the opportunity to comment upon the proposed plan of the Interdepartmental Committee and to continue to share in the Committee's activities.

Sincerely yours,

E. L. PETERSON,
Assistant Secretary.

DEPARTMENT OF STATE,
Washington, February 24, 1960.

Mr. H. HERBERT HUGHES,
Chairman, Interdepartmental Committee on Radiation Preservation of Food, Department of Commerce.

DEAR MR. HUGHES: I wish to acknowledge your letter to the Secretary of February 17, 1960, enclosing the report, "A National Civilian Radiation Processed Foods Program," prepared by an ad hoc working group for the Interdepartmental Committee on Radiation Preservation of Foods.

The Department of State has reviewed the report and has no comment to make.

Sincerely yours,

CHARLES A. SULLIVAN,
Deputy Special Assistant to the Secretary.

THE SECRETARY OF COMMERCE,
Washington, D.C., March 14, 1960.

Mr. H. HERBERT HUGHES,
Chairman, Interdepartmental Committee on Radiation Preservation of Food, U.S. Department of Commerce, Washington, D.C.

DEAR MR. HUGHES: This will acknowledge your letter of February 17, 1960, and the enclosed copies of the report entitled "A National Civilian Radiation Processed Foods Program." This was transmitted for Department of Commerce review and comments.

The report has been studied by appropriate members of the Department's staff. It is realized that irradiation of food offers promise for the future; therefore, a development of a national civilian program is outlined in the above-mentioned report seems as important and appropriate step forward in accelerating the introduction of radiation processed foods into our civilian economy.

The Department of Commerce, therefore, supports the recommendations found in the above-mentioned report.

Sincerely yours,

F. H. MUELLER,
Secretary of Commerce.

SMALL BUSINESS ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., March 11, 1960.

Mr. H. HERBERT HUGHES,
Chairman, Interdepartmental Committee on Radiation Preservation of Food, U.S. Department of Commerce, Washington, D.C.

DEAR MR. HUGHES: I have reviewed the ad hoc panel report which proposes a national civilian radiation processed foods program and, in my opinion, the substances of this report should be accepted by the Committee as the basis of an integrated national civilian program. As a practical matter I agree that the Government, for the time being, must assume primary responsibility for further research and development and the establishment of pilot facilities in the civilian application of radiation to preserve foods.

May I express the hope that in the further development of this program the capabilities and facilities of qualified small business concerns will be utilized to the maximum extent.

Sincerely yours,

PHILIP MCCALLUM, *Administrator.*

INTERNATIONAL COOPERATION ADMINISTRATION,
OFFICE OF THE DIRECTOR,
Washington, D.C., March 7, 1960.

Mr. H. HERBERT HUGHES,
Chairman, Interdepartmental Committee on Radiation Preservation of Food, U.S. Department of Commerce, Washington, D.C.

DEAR MR. HUGHES: This will acknowledge your letter of February 17 enclosing a copy of the report entitled "A National Civilian Radiation Processed Foods Program" for ICA's review and comments.

The report has now been studied by appropriate members of our staff. It is realized that, while irradiation of food offers considerable promise for the future, development has not yet reached the point of commercial or economic feasibility; hence, its applicability to the ICA technical assistance program overseas must still be considered as a matter for the future.

We believe, however, that the establishment of an integrated national civilian program as outlined in the aforementioned report is an important step in accelerating the introduction of radiation processed foods into our economy, which in turn would hasten the time when ICA could utilize feasible processes in its own programs abroad. ICA therefore supports the recommendations in said report.

With every good wish,
Sincerely yours,

JAMES W. RIDDLEBERGER.

THE SECRETARY OF HEALTH, EDUCATION, AND WELFARE,
Washington, March 16, 1960.

Mr. H. HERBERT HUGHES,
Chairman, Interdepartmental Committee on Radiation Preservation of Food, U.S. Department of Commerce, Washington, D.C.

DEAR MR. HUGHES: Reference is made to your letter of February 17, 1960, transmitting the ad hoc panel report on "A National Civilian Radiation Processed Foods Program."

We have reviewed the report and have no particular comments to offer. We shall be glad to continue cooperation with the Interdepartmental Committee.

Sincerely yours,

ARTHUR S. FLEMMING, *Secretary.*

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 12, 1960.

Mr. H. HERBERT HUGHES,
Chairman, Interdepartmental Committee on Radiation Preservation of Food, U.S. Department of Commerce, Washington, D.C.

DEAR MR. HUGHES: The Commission has considered the report on a "National Civilian Radiation Processed Foods Program" transmitted with your February 17, 1960, letter. We have approved the undertaking by AEC of a program of research and development on low dose radiation processing of food to extend shelf life. The relationship of this program to that proposed by the Interdepartmental Committee is described in the enclosure to this letter.

The Commission's staff will discuss fully our consideration of the Interdepartmental Committee report in establishing the AEC program at the committee meeting planned for March 21, 1960.

The Commission has already established a strong liaison with the Department of the Army concerning the latter's high dose food irradiation program. This liaison will be maintained and strengthened to assure proper coordination between the high dose and low dose programs.

The Commission is willing to act as the coordination point for the interests of other Government agencies in low dose food irradiation processing.

Sincerely yours,

A. R. LUEDECKE, *General Manager.*

SUMMARY STATEMENT OF AEC RADIATION PROCESSED FOODS PROGRAM

1. The AEC radiation processed foods program is consistent in scope and with the objectives of the Interdepartmental Committee on Radiation Preservation of Food report formulating a national civilian radiation processed fooods program.

Emphasis under the AEC program will be placed on basic studies in food chemistry, microbiology, wholesomeness testing, preservation factors of shelf life extension, and radiation process technology with a focus on a small number of selected foods which appear to promise early technical feasibility and marketability.

2. Because of the time required to establish the specific details of a sound integrated program, however, it does not appear feasible to proceed initially as rapidl yas suggested in the Interdepartmental Committee report.

(*a*) Initial start-up studies must be completed to establish the specific elements of a research program on wholesomeness and safety of low-dose processed foods, including interrelated work such as radiation effects, process, and preservation factors for shelf life extension, as well as selection of specific foods for study under the program.

(*b*) These considerations involve specific identification with the Food and Drug Administration of the scientific protocol to be followed in the establishment of safety of low-dose radiation processed foods and their final clearance.

(*c*) It is expected that development of a fully defined research and wholesomeness program will require approximately 6 to 8 months for completion.

3. The Commission has approved expenditure of funds in the amount of $115,000 in fiscal year 1960 and $500,000 in fiscal year 1961 for initial start-up of this new program with a projected total operating expenditure of approximately $5 million over a 5-year period.

4. The Interdepartmental Committee report established a total operating budget of $4.455 million over a 4-year period with alternative construction moneys of $1.4 million for a national center or $550,000 for a marine products irradiator.* The funding level set forth in the Interdepartmental Committee report of $400,000 in fiscal year 1960 and $920,000 in fiscal year 1961 assumed completion of startup studies to define the required research program within fiscal year 1960 which will be impossible due to the longer time required to develop and consider the report than originally envisioned.

5. The Interdepartmental Committee report identified different types of irradiation facilities as an integral and basic part of the radiation processed foods program. These included:

(*a*) *Portable laboratory research irradiators*

Portable laboratory research irradiators with 10,000 to 20,000 curies of cobalt 60 would be used to carry out basic studies to establish wholesomeness and safety of low dose radiation processed food as well as to investigate the origin and control of factors affecting the foods' odor, taste, color, and texture.

The Interdepartmental Committee report proposed four such irradiators, two in fiscal year 1960 and two in fiscal year 1961.

The AEC program as approved provides for two laboratory research irradiators through fiscal year 1961. The need for additional research irradiators will be determined as the Commission's program becomes more fully developed.

---

*The Interdepartmental Committee report proposes construction of a marine products irradiator to be located near an important east coast fishing port if—

1. A national center is not constructed; or
2. Such a center is constructed but not in a geographical area convenient to a commercial fishery center.

A portable laboratory research irradiator, including a 20,000 curie cobalt 60 source is estimated to cost $40,000. This assumes procurement of cobalt 60 on an AEC cost fund basis.

(*b*) *Mobile field process irradiators*

Mobile field process irradiators with 50,000 to 150,000 curies of cobalt 60 would be used to test process selected foods at places where they are harvested and packaged for transportation to markets.

The Interdepartmental Committee report proposed two such irradiators in fiscal year 1961.

Mobile irradiators are not provided for within fiscal year 1960 and fiscal year 1961 funds approved by the Commission for startup of its radiation processed food program. The requirement for irradiators of this type in the AEC program will be determined as the program becomes more fully developed.

A mobile field process irradiator, including a 100,000 curie cobalt 60 source is estimated to cost $150,000. This assumes procurement of cobalt 60 on an AEC cost fund basis.

(*c*) *National center*

A national center integrating a highly flexible 1 million curie cobalt 60 irradiator with research and food preparation facilities would be used for conduct of research and development on process specifications and quality control factors as these influence the acceptability of radiation processed food products.

The Interdepartmental Committee report proposed establishment of a national center in fiscal year 1962 at a cost of $1.4 million. Establishment of such a center assumed a concurrent need by the Department of the Army and the civilian program.

The Department of the Army has not yet announced its plans with respect to research facilities for its radiation sterilization of foods program.

The AEC food program presently envisions partial use of the High Intensity Radiation Development Laboratory to be constructed at the Brookhaven National Laboratory for conduct of experimental process development on food which might otherwise have been performed at the national center. This use will require limited modification of the facility. It is to be noted, however, that the Brookhaven facility, as originally authorized, will be used primarily for radiation source and engineering development, as well as radiation studies on chemical systems, etc.

As the AEC radiation processed foods program becomes more fully developed, a requirement for a research center of the type proposed by the Interdepartmental Committee report may be established or some modification thereof, i.e., a marine products radiation research center and an agricultural products radiation research center.

DEPARTMENT OF THE ARMY,
OFFICE OF THE DIRECTOR OF RESEARCH AND DEVELOPMENT,
Washington, D.C., March 14, 1960.

Mr. H. HERBERT HUGHES,
Chairman, Interdepartmental Committee on Radiation Preservation of Food, Department of Commerce, Washington, D.C.

DEAR MR. HUGHES: The Department of the Army has completed a study of the report, "A National Civilian Radiation Processed Foods Program," as you requested in your February 17, 1960, letter addressed to the Secretary of the Army.

The Department of the Army concurs in the report. Minor editorial comment is furnished at enclosure 1.

The revised Army Food Irradiation Program should lend considerable support to your proposed civilian program. Our reoriented program includes seven research tasks in the areas of military applications and economic analyses, assurance of wholesomeness, pre- and postirradiation studies, destruction of micro-organisms, nuclear effects on foods, acceptance testing and development of packaging. Research on these tasks will be performed over a 6-year period at an estimated cost of $5.130 million. Integral to the Army program is the proposed construction of an irradiated food research facility to cost an estimated $1.8 million. This facility will consist of a megacurie cobalt 60 gam-

ma irradiator; a 1 to 12 Mev. (million electron volts) variable voltage linear electron accelerator; and minimal associated food preparation and laboratory facilities. No site has, as yet, been selected for this facility. It is expected the facility will be available during fiscal year 1962.

I should like to clarify one point which I feel the proposed civilian program does not adequately stress. The Army, by virtue of its reorientation of the national effort which it has spearheaded since 1954, has not lessened its interest in the furtherance of the national and international objectives in the radiation preservation of food field. The realinement of our program was necessitated by the advent of unforeseen complex fundamental research problems. The resolution of these problems demanded the readjustment of the original time phasing of the Army program.

The original Army program, while emphasizing research in high dose treatment (sterilization) of foods, did not neglect the technique of low dose treatment (pasteurization). As the civilian program states, these two areas are complementary. Thus, it follows that certain of the problems encountered in the high dose treatment area must be solved satisfactorily before complete success can be realized in the low dose treatment area. The more difficult problems appear to lie in the area of high dose treatment. It seems entirely logical, therefore, to place prime emphasis in the revised Army research program on the solution of these more complicated problems.

In my view, the Army will continue to make the major future contribution to the fund of available basic knowledge which will ultimately make possible the final determination concerning the role of radiation preserved foods in the National and International economies.

The Army welcomes any and all assistance in this effort. We are particularly pleased that the member agencies of your Committee have seen fit to participate more actively in the advancement of this program. The broadening of the national research base in the radiation preservation of foods field is an important step which will most certainly facilitate our mutual objective of early transition to industry.

Secretary Brucker has asked me to convey his appreciation for the past support your Committee has furnished the Army program and for the added active program participation your member agencies envision.

I can assure you that the Army will continue to offer maximum cooperation to the Interdepartmental Committee on Radiation Preservation of Food and to its member agencies. The Army Irradiated Food Research facilities will be made available, on a reimbursable basis, for use by your member agencies, to the maximum extent possible.

Sincerely,

RICHARD S. MORSE,
Director of Research and Development.

ARMY COMMENTS ON THE REPORT OF THE INTERDEPARTMENTAL COMMITTEE ON RADIATION PRESERVATION OF FOOD "A NATIONAL CIVILIAN RADIATION PROCESSED FOOD PROGRAM."

1. Recommendation 4, page 4, added at the February 12, 1960 meeting of the Interdepartmental Committee should be changed to read: "The Army complete its wholesomeness and safety program and that the operating agency initiate such complementary wholesomeness and safety work as may be required for the civilian radiation processed foods program." This recommended change will reflect that the Army's wholesomeness program is not restricted to sterilization dosage; the Army's program is of much broader scope than just resolution of experimental anomalies; a complementary national civilian wholesomeness program should not be limited to substerilization dosages.

2. Recommendation 5, page 4, added at the February 12, 1960 meeting of the Interdepartmental Committee should be changed to read: "A wholesomeness and safety program working panel to the Interdepartmental Committee be established consisting of Army, Atomic Energy Commission, Food and Drug Administration, U.S. Department of Agriculture, and consultants as required to coordinate this program." Participants from the member agencies represented on

this working panel should possess a medical background. This recommended change adds "And safety" to bring the report's fifth recommendation in consonance with the wording in the report's fourth recommendation.

3. It is recommended that the funding level for supplementary wholesomeness studies (p. 24 of report) be revised upward thus providing for the work necessary to resolve problems of induced radioactivity related to the legal clearance for marketing of foods under Public Law 85–929.

4. Recommend last sentence, section VI, page 16, be changed to read: "Progress is being limited by the need for additional gamma irradiators or variable energy x-ray and electron sources to develop the best and most economic conditions for radiation processing of a wide variety of food products."

5. Recommend last sentence, page 29, be changed to read: "It will also be desirable to examine the suitability of variable energy electron accelerators for the radiation processing of foods."

6. Preceding recommendations 4 and 5 are believed to be more descriptive of existing conditions with respect to availability of radiation sources and provide for increased flexibility in the research program.

Appendix 2

MEDICAL NUTRITION LABORATORY

AN ASSESSMENT OF THE POSSIBLE EFFECTS TO HUMAN BEINGS OF SHORT-TERM CONSUMPTION OF FOOD STERILIZED WITH GAMMA RAYS

REPORT 203
25 MAR. 1957

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AN ACTIVITY OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

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U. S. ARMY MEDICAL NUTRITION LABORATORY
Fitzsimons Army Hospital
Denver 8, Colorado

Report No. 203

25 March 1957

Report of

AN ASSESSMENT OF THE POSSIBLE TOXIC EFFECTS TO HUMAN BEINGS OF SHORT-TERM CONSUMPTION OF FOOD STERILIZED WITH GAMMA RAYS

by

Lester M. Levy, Capt., MC
Lionel M. Bernstein, M.D., Ph.D.
Eugene Francis, SP2, AMEDS (M.A.)
Richard S. Harding, B.S.
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Conclusions stated are subject to change on the basis of additional evidence. Information contained herein is not to be reprinted or published without written permission from Research and Development Division, Office of The Surgeon General, Department of the Army, Washington 25, D. C.

Report No. 203
Project No. 6-60-11-020
USAMNL Subproject No. 12
Work Phases 1-4

25 March 1957

AN ASSESSMENT OF THE POSSIBLE TOXIC EFFECTS TO HUMAN BEINGS OF SHORT-TERM CONSUMPTION OF FOOD STERILIZED WITH GAMMA RAYS

OBJECT:

The assessment of possible toxic effects to human beings of the short-term consumption of food exposed to gamma rays at a dosage of 3 million rep.

SUMMARY:

Eighteen human volunteers consumed for short periods of time (15 days) food exposed to 3 million rep gamma rays and stored frozen until used. Four such studies were conducted in which 35%, 60%, 80% and virtually 100% of the calories were supplied by irradiated items of food. These studies were separated by intervals of several months. Careful clinical and laboratory observations revealed no evidence that these irradiated foods produced any toxic effects in the human beings consuming them.

RECOMMENDATION:

Further tests should be made in human beings of the safety of a wider variety of irradiated foods, and also of irradiated foods which have been stored at room temperature.

APPROVED:

Theodore E. Friedemann

THEODORE E. FRIEDEMANN, Ph.D.
Scientific Director

Carl J Koehn

CARL J. KOEHN
Lt. Colonel, MSC
Deputy Commanding Officer

L. M. Hursh

L. M. HURSH
Lt. Colonel, MC
Commanding

INTRODUCTION

The two major objectives of food preservation are the destruction or inhibition of micro-organisms and of proteolytic enzymes. In canning, both bacteria and enzymes are destroyed by heat, while in freezing the action of bacteria and enzymes are effectively retarded. The treatment of food with ionizing radiation in sufficient dosage to kill micro-organisms offers a new approach to food preservation.

Important sources of ionizing radiations now available for this purpose are high voltage electron accelerators and gamma emitting radioisotopes from atomic reactors. Micro-organisms are effectively destroyed in food which is irradiated at a dosage of one to three million roentgen-equivalents-physical (rep) (20). At a dosage of three to 10 million rep the enzymes in food may be inactivated. Doses far smaller than these are effective in controlling insect infestation of grain (5), in destroying trichinae in meat products (6), and in preventing the sprouting of potatoes and onions (2, 23).

None of these levels of radiation are sufficient to induce radioactivity in the food so treated. However, some chemical changes are produced which, although of small magnitude, are detectable and result in changes in flavor, texture, color and odor. There are three potential hazards to health from the chemical changes in food induced by ionizing radiation. The first is the destruction of essential nutrients such as vitamins and amino acids (1, 7, 19). The second hazard is the production of toxic compounds (9). The third is the production by irradiation of substances which upon prolonged ingestion may be carcinogenic (24).

The Office of the Quartermaster General of the United States Army has organized an elaborate program to explore the potentialities of the use of radiation in food preservation. The investigation of the nutritional aspects and possible toxic effects of such irradiated foods is under the auspices of the Office of the Surgeon General of the United States Army. Individual irradiated foods are first fed to animals (8, 15, 16, 17, 18). If there are no detrimental effects in animals, the palatability of such foods is evaluated by a panel of professional testers. These individuals are under continuous careful medical supervision. Foods considered palatable are then fed to human beings. The present report describes the results of four feeding studies performed on the Metabolic Research Ward of the U. S. Army Medical Nutrition Laboratory, Fitzsimons Army Hospital, Denver, Colorado.

Irradiated foods were fed to human volunteers for periods of 15 days. The men who received these foods were followed carefully by physical examinations and clinical laboratory tests for a period of a year after feeding. It is obvious that this program cannot be expected to detect nutritional deficiencies or possible carcinogenic effects. The tests should, however, detect the presence of significant amounts of chemical compounds resulting from irradiation which could produce toxic changes manifested after a short latency period. It must also be pointed out that the irradiated food used in these studies was stored frozen until used. The study, therefore, is not a test of the ability of

irradiation to preserve food but only of possible health hazards of irradiation alone. The acceptability of the foods used in these studies and the measurements of metabolizable energy and digestibility of the macronutrients are reported elsewhere (10, 13).

METHODS

Test Subjects.

Eighteen men have taken part in this program to date. The test subjects were conscientious objectors of the Mennonite Faith who volunteered for the program as a means of fulfilling their obligation to Selective Service. These men were all between 18 and 22 years of age and passed a careful medical examination before admission to the test. One subject (RED) was later found to have had an acute attack of infectious hepatitis the year before the test. Although he was apparently well, on some occasions tenderness was noted in the region of the liver and his thymol turbidity test was persistently slightly elevated.

During the study the men lived on the Metabolic Ward. They were enthusiastic supporters of the program, almost all of them with previous experience in metabolic study programs. Table I summarizes the subject participation in the four studies.

General Plan of the Studies.

Each study consisted of two 15-day periods separated by an interval of three to seven days of rest. During the first 15-day study period, half of the subjects received the diet containing the irradiated food items and the other half received the control diet. During the second 15-day period the situation was reversed. In order to prevent accumulation of possible toxic effects several months intervened between studies. Successive studies provided a greater variety of irradiated foods and an increasing percentage of total calories from irradiated items. In the first study approximately 35% of the total calories were supplied as irradiated food; in the second, 60%; and in the third, 80%. In the last study, essentially all of the calories were provided as irradiated food; only cocoa was unirradiated. In the first three studies, metabolic balances were performed in order to measure digestibility and metabolizable energy. These studies required that the foods be as homogeneous as possible. The fourth study was not a metabolic balance study so that it was possible to present a greater variety of foods in a more attractive manner. In the first three studies, three daily menus were used; in the fourth study, five rotating menus were used (tables III, IV, V, VI).

Food Procurement and Preparation.

All test foods, both irradiated and control, were ordered through the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois. All foods, except white and sweet potatoes, were placed in either #2 or #10 cans and frozen. Half of each food item stocked was shipped by air to Arco, Idaho or Dugway, Utah for irradiation by gamma rays of a mixed spectrum at a dosage of three million rep. All test foods, both irradiated and control, were held in the frozen state until the time of use, except those normally stored at room temperature. White and sweet potatoes, which were irradiated only to prevent sprouting, received

a gamma ray dosage of 20,000 rep. All test foods, both irradiated and control, came from the same original batch, except in the second study. Non-test foods which were used to provide the balance of calories in the first three studies were procured through the Post Commissary.

Details of food preparation are given elsewhere (12). Whenever possible, food was weighed, cooked and served in the same containers. Each man received the same menu independent of his weight or caloric requirement. He consumed it totally; containers were literally licked clean and glasses were washed several times with water, the washings being consumed by the subjects.

Clinical Tests.

Each man received a careful physical examination and an electrocardiogram was recorded before, during and after each feeding of irradiated food and at intervals of three, six and 12 months after his last consumption of irradiated food. Six of the 18 subjects have now been followed for 12 months after their last feeding of irradiated food; the remaining men for six months. Every morning on arising, each man was weighed in the nude after voiding. Several times each day blood pressures, pulse, respiration and body temperature were measured. Every day each man was carefully questioned for any symptoms suggesting toxic effects from the irradiated food.

Laboratory Tests.

Before, during and at intervals after each irradiated food study, a series of laboratory tests were performed to detect any possible toxic effects of the irradiated food. The tests were as follows: hematology: hemoglobin (4), hematocrit, and total and differential white blood cell count (14); liver function: bromsulphalein retention after 45 minutes (22), total protein, albumin, globulin and albumin-globulin ratio in serum (3), alkaline phosphatase (21), total and direct bilirubin (11), and thymol turbidity (14); renal function: complete urine analysis and phenolsulfonephthalein excretion test (14).

RESULTS

Clinical Tests.

No evidence could be found of any toxic effects induced by the irradiation treatment of food. Physical examinations showed no abnormalities except those common in a group of young men observed for a prolonged period of time. There was the usual seasonal incidence of infections of the upper respiratory tract. Occasional headaches were noted, as was some muscle soreness apparently related to participation in athletics. There were no gastro-intestinal symptoms such as nausea, vomiting, diarrhea, constipation or rectal irritation that could be related to the ingestion of irradiated foods. One subject developed nausea and vomiting on the ingestion of shrimp which he had never consumed previously and disliked intensely. He was finally able to tolerate both control and irradiated shrimp when it was minced with potatoes and green beans and served in the form of a casserole. Another subject (SCH), an extremely "finicky" eater could not tolerate the variety of foods fed during the metabolic balance studies. His

intolerance was equally marked for the control and irradiated items; this obliged him to leave the experiment after the second study was completed. The remainder of the 18 test subjects tolerated the irradiated food without incident.

Electrocardiograms showed no significant abnormalities. There were no changes in blood pressure, pulse, respiration or body temperature except those associated with colds and other disorders unrelated to the study. In table VII the mean body weight of each subject before consumption of irradiated food is compared with his last observed weight. There were no significant changes. In general the weight of each man fluctuated as a function of the extent to which the test diet satisfied his caloric requirement. Thus, heavier men tended to lose while smaller men tended to gain weight.

Laboratory Tests.

The detailed laboratory data are given in the appendix. The average control values and the value of the last observation for each man are summarized in table VII. Urine analyses, the results of which were too voluminous to include in the report, showed no significant changes throughout the studies. Some of the men experienced difficulty with the first one or two phenolsulfonephthalein excretion tests. Later results were within normal limits. The differential white blood cell counts showed considerable variation within the normal range. Results of several of the laboratory tests, particularly those for hemoglobin and serum protein, tended to fluctuate from day to day. This variation was present in men on both irradiated and control foods and did not exceed the generally accepted normal values for the particular tests. In some men, certain values obtained before any irradiated food had been consumed were outside accepted normal range. Thus, one individual (SIE) showed a value for total serum bilirubin persistently above 1.0 mg per 100 ml. Such idiosyncrasies in laboratory tests showed no tendency to fluctuate with the feeding of irradiated food. It may be seen from table VII that the mean values of the last determination of a particular laboratory test are very close to the mean control value. Over all, there were no changes in any laboratory tests that could be related to the feeding of irradiated food.

DISCUSSION

Clinical and laboratory examinations of 18 human volunteers who consumed irradiated food failed to demonstrate any deleterious effect to general health or damage to blood forming organs, liver or kidneys, that could be related to the ingestion of irradiated food. As noted in the introduction, the study reported here could detect only evidence of short latency toxicity. The present study could not be expected to detect deficiencies in the food of vitamins or other essential substances or the presence in the food of carcinogenic materials. The negative results of the present report, however, do encourage further exploration of the use of irradiation in food preservation. The next step planned involves short term testing in humans of irradiated foods stored at room temperature between irradiation and consumption. The animal tests which must necessarily precede such a study are already under way. Long term animal studies

are also being carried out to evaluate nutritional adequacy or possible carcinogenicity. When a sufficient number of these studies are completed, long term human studies are planned to evaluate the nutritional adequacy of irradiated foods as well as any toxic effects.

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TABLE I

SUBJECT PARTICIPATION IN IRRADIATED FOOD STUDIES

STUDY	15F35 (I)	15F60 (II)	15F80 (III)	15F100 (IV)
% IRRADIATED CALORIES	35%	60%	80%	100%
TIME OF STUDY	May-Jun '55	Sep-Oct '55	Jan-Feb '56	Apr-May '56
SUBJECTS:				
GOE	X			
MIL	X			
PAN	X			
SMI	X			
THI	X			
MEY	X	X	X	
SIE	X	X	X	
ERB	X	X	X	X
RED	X	X	X	X
SCH		X		
HOL		X	X	X
LEP		X	X	X
MAU		X	X	X
PRE		X	X	X
UNR		X	X	X
HEI			X	X
HUE				X
PLE				X

*Note: First figure - length of feeding period in days; F - food stored frozen; second figure - per cent of caloric intake provided by irradiated food.

TABLE II

IRRADIATED FOODS EMPLOYED IN HUMAN FEEDING STUDIES

MEATS AND FISH	VEGETABLES	FRUITS
Bacon, ground, sliced	Asparagus	Apricots, dried
Beef, corned	Beans, green	Cherries
Beef, ground, steak	Beans, Lima	Melon balls
Frankfurters	Beets	Peaches
Ham, ground, steak	Brussels Sprouts	Pears, dried
Haddock	Cabbage	Strawberries
Tuna	Carrots	
Salmon	Cauliflower	
Sausage	Celery	
Shrimp	Corn	
	Mushrooms, dried	
	Peas	
	Potatoes, sweet	
	Potatoes, white	

MISCELLANEOUS	CEREAL PRODUCTS
Dessert Powder	Bread
Milk, powdered	Crackers
Peanut butter	Cereal bar
Strawberry jam	Macaroni
Sugar	Nut roll
	Pound cake
	Rice

TABLE III

MENUS OF IRRADIATED FOOD STUDY 15F35 (I)
35 Per cent of Calories Irradiated

MENU 1		MENU 2		MENU 3	
FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.
BREAKFAST		BREAKFAST		BREAKFAST	
*Frozen Peaches	100	Tomato Juice	200	Frozen Orange Juice	185
*Cereal Bar	30	Rice Krispies	30	*Cereal Bar	30
Fried Eggs	100	Scrambled Eggs with	100	Fried Eggs	100
		*Ground Bacon	50		
*Toast	25	*Toast	25	*Toast	25
Butter	15	Butter	10	Butter	15
Grape Jelly	14	Apple Jelly	14	Currant Jelly	14
Milk	240	Milk	240	Milk	240
Sugar	14	Sugar	14	Sugar	14
Coffee or Tea		Coffee or Tea		Coffee or Tea	
LUNCH		LUNCH		LUNCH	
*Broiled Beef Patties	200	Roast Turkey (White Meat)	120	*Baked Ham Loaf	100
Catsup	20	Cranberry Jelly	14		
Steamed Potatoes	100	Steamed Noodles	30	Sweet Potatoes	100
*Beets	60	*Green Beans	60	Lima Beans	80
*Bread	25	*Bread	25	*Bread	25
Butter	10	Butter	10	Butter	10
Vanilla Ice Cream	100	*Frozen Peaches	100	*Frozen Strawberries	100
				in Jello	17
*Cocoa		*Cocoa		*Cocoa	
Powdered Whole Milk	30	Powdered Whole Milk	30	Powdered Whole Milk	30
Sugar	21	Sugar	21	Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5
Coffee or Tea		Coffee or Tea		Coffee or Tea	
DINNER		DINNER		DINNER	
Roast Turkey (White Meat)	120	*Broiled Beef Patty	200	*Baked Haddock	100
Cranberry Jelly	14	Catsup	20		
Steamed Potatoes	100	Steamed Potatoes	100	Steamed Potatoes	100
*Green Beans	60	Carrots	80	Peas	60
Bread	25	Hamburger Buns	45	Bread	25
Butter	10	Butter	10	Butter	10
*Frozen Strawberries	100	Vanilla Ice Cream	100	Canned Pears	100
in Jello	17				
Vanilla Wafers	19				
Milk	240	*Cocoa		Milk	240
Sugar	7	Powdered Whole Milk	30	Sugar	7
		Sugar	21		
		Cocoa	5		
8 PM		8 PM		8 PM	
Canned Pineapple Chunks	100	Canned Apricots	100	Canned Applesauce	100
Graham Crackers	40	Lorna Doon Cookies	40	Angel Food Cake	40
Milk	240	Milk	240	Milk	240

* Irradiated

TABLE IV

MENUS OF IRRADIATED FOOD STUDY 15F60 (II)
61 Per cent of Calories Irradiated

MENU 1		MENU 2		MENU 3	
FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.
BREAKFAST		BREAKFAST		BREAKFAST	
*Pears, Dried	75	*Frozen Peaches	100	Tomato Juice	200
*Cereal Bar	30			*Cereal Bar	30
Fried Eggs	100	Scrambled Eggs with	100	Fried Eggs	100
		*Ground Bacon	30		
*Toast	50	*Toast	50	*Toast	50
Butter	15	Butter	10	Butter	15
Apple Jelly	14	Currant Jelly	14	Grape Jelly	14
Milk	240	Milk	240	Milk	240
Sugar	14	Sugar	7		
Coffee or Tea		Coffee or Tea		Coffee or Tea	
LUNCH		LUNCH		LUNCH	
*Baked Haddock	120	*Broiled Beef Patty	150	*Steamed Shrimp	120
		Catsup	20	Catsup	20
Steamed Potatoes	100	Steamed Macaroni	30	Steamed Potatoes	100
*Beets	50	*Peas	100	*Green Beans	60
*Bread	50	*Bread	50	*Bread	50
Butter	10	Butter	10	Butter	10
*Frozen Peaches	100	*Frozen Strawberries	100	*Frozen Peaches	100
		in Jello	17	*Pound Cake	40
*Chocolate Milk		*Chocolate Milk		*Chocolate Milk	
*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30
Sugar	21	Sugar	21	Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5
Coffee or Tea		Coffee or Tea		Coffee or Tea	
DINNER		DINNER		DINNER	
*Sausage Patties	150	*Baked Ham Loaf	100	*Broiled Beef Patty	150
Catsup	20			Catsup	20
*Steamed Macaroni	30	Steamed Potatoes	100	*Steamed Macaroni	30
Carrots	80	*Green Beans	60	*Peas	100
*Bread	50	*Bread	50	*Bread	50
Butter	10	Butter	10	Butter	10
*Frozen Strawberries	100	*Dried Pears	75	Vanilla Ice Cream	100
in Jello	17				
*Pound Cake	40				
*Chocolate Milk		*Chocolate Milk		*Chocolate Milk	
*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30
Sugar	21	Sugar	21	Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5
Coffee or Tea		Coffee or Tea		Coffee or Tea	

* Irradiated

TABLE V

MENUS OF IRRADIATED FOOD STUDY 15F80 (III)
80 Per cent of Calories Irradiated

MENU 1		MENU 2		MENU 3	
FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.
BREAKFAST		BREAKFAST		BREAKFAST	
*Frozen Cherries	100	*Dried Pears	75	*Frozen Peaches	100
Scrambled Eggs with	100	Scrambled Eggs with	100	Scrambled Eggs with	100
*Sausage	100	*Ground Bacon	50	*Sausage	100
*Toast	50	*Toast	50	*Toast	50
Butter	10	Butter	10	Butter	10
*Cocoa		*Cocoa		*Cocoa	
*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30
Sugar	21	Sugar	21	Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5
Sugar	7				
LUNCH		LUNCH		LUNCH	
*Steamed Tuna	100	*Steamed Frankfurters	100	*Baked Salmon	100
		Mustard	10		
*Steamed Macaroni	30	*Steamed Macaroni	30	*Steamed Potatoes	100
*Lima Beans	80	*Brussels Sprouts	80	*Cauliflower	80
*Crackers	25	*Bread	50	*Bread	50
Butter	10	*Peanut Butter	20	Butter	10
*Frozen Peaches	100	*Frozen Melon Balls	100	*Dessert Ice	
*Pound Cake	40	*Pound Cake	40	*Dessert Powder	20
				*Powdered Whole Milk	10
*Chocolate Milk		*Chocolate Milk		*Chocolate Milk	
*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30
Sugar	21	Sugar	21	Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5
DINNER		DINNER		DINNER	
*Baked Meat Loaf	200	*Baked Corned Beef	100	*Broiled Beef Patty	200
Catsup	20			*Mushrooms	5
*Steamed Potatoes	100	*Steamed Potatoes	100	*Steamed Rice	30
*Celery	75	*Cabbage	60	*Asparagus	80
		*Carrots	80		
*Bread	50	*Bread	50	*Bread	50
*Peanut Butter	20	*Peanut Butter	20	*Peanut Butter	20
*Dessert Ice		*Frozen Cherries	100	*Frozen Strawberries	100
*Dessert Powder	20			*Pound Cake	40
*Powdered Whole Milk	10				
*Chocolate Milk		*Chocolate Milk		*Chocolate Milk	
*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30
Sugar	21	Sugar	21	Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5
		Sugar	7		

* Irradiated

TABLE VI

MENUS OF IRRADIATED FOOD STUDY 15F100 (IV)
100 Per cent of Calories Irradiated

MENU 1		MENU 2		MENU 3		MENU 4		MENU 5	
FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.
BREAKFAST		BREAKFAST		BREAKFAST		BREAKFAST		BREAKFAST	
*Frozen Peaches	100	*Frozen Cherries	100	*Stewed Pears	75	*Frozen Strawberries	100	*Stewed Apricots	75
*Cereal Bar	30	*Steamed Rice with	30	*Cereal Bar	30	*Steamed Rice with	30	*Cereal Bar	30
		*Sugar and Cinnamon	7			*Sugar and Cinnamon	7		
		*Broiled Bacon	30			*Broiled Bacon	30		
*Toast	50	*Toast	50	*Toast	50	*Toast	50	*Toast	50
*Strawberry Jam	20	*Strawberry Jam	20	*Strawberry Jam	20	*Strawberry Jam	20	*Strawberry Jam	20
*Cocoa		*Cocoa		*Cocoa		*Cocoa		*Cocoa	
*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30
*Sugar	21	*Sugar	21	*Sugar	21	*Sugar	21	*Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5	Cocoa	5	Cocoa	5
*Sugar	14	*Sugar	14	*Sugar	14	*Sugar	14	*Sugar	14
LUNCH		LUNCH		LUNCH		LUNCH		LUNCH	
*Broiled Ham Steak	200	*Steamed Frankfurters	125	*Tuna-Macaroni Casserole		*Broiled Tenderloin Steak with	200	*Baked Filet of Haddock	100
				*Tuna	75	*Mushrooms	5		
				*Macaroni	30				
				*Crackers	20				
*Candied Sweet Potatoes	150	*Julienne Potatoes	150			*Mashed Potatoes	150	*Diced Potatoes	150
*Peas	100	*Seasoned Green Beans	100	*Seasoned Lima Beans	100	*Brussels Sprouts	100	*Seasoned Corn	100
*Bread	50	*Bread	50	*Bread	50	*Bread	50	*Bread	50
*Peanut Butter	20	*Peanut Butter	20	*Peanut Butter	20	*Peanut Butter	20	*Peanut Butter	20
*Nut Roll	50	*Dried Apricots	75	*Strawberry Short Cake		*Nut Roll	50	*Frozen Melon Balls	100
				*Strawberries	100				
				*Pound Cake	40				
*Chocolate Milk		*Chocolate Milk		*Chocolate Milk		*Chocolate Milk		*Chocolate Milk	
*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30
*Sugar	21	*Sugar	21	*Sugar	21	*Sugar	21	*Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5	Cocoa	5	Cocoa	5
*Sugar	14	*Sugar	14	*Sugar	14	*Sugar	14	*Sugar	14

-Continued-

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TABLE VI (Cont.)

MENUS OF IRRADIATED FOOD STUDY 15F100 (IV)
100 Per cent of Calories Irradiated

MENU 1		MENU 2		MENU 3		MENU 4		MENU 5	
FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.	FOOD ITEM	WEIGHT Gm.
DINNER		DINNER		DINNER		DINNER		DINNER	
*Baked Meat Loaf	200	*Broiled Tenderloin Steak	200	*Baked Sausage	150	*Baked Corned Beef	100	*Baked Ham Patties	150
*with Mushrooms	5								
*Steamed Macaroni	30	*Oven-Browned Potatoes	150	*Baked Potatoes	150	*Boiled Potatoes	150	*Steamed Macaroni	30
*Asparagus	100	*Beets	100	*Peas	100	*Seasoned Cabbage	100	*Cauliflower	100
						*Carrots	100		
*Bread	50	*Bread	50	*Bread	50	*Bread	50	*Bread	50
*Peanut Butter	20	*Peanut Butter	20	*Peanut Butter	20	*Peanut Butter	20	*Peanut Butter	20
*Frozen Melon Balls	100	*Dessert Ice		*Frozen Cherries	100	*Peach Short Cake		*Dessert Ice	
		*Dessert Powder	20			*Peaches	100	*Dessert Powder	20
		*Powdered Whole Milk	10			*Pound Cake	40	*Powdered Whole Milk	10
*Chocolate Milk		*Chocolate Milk		*Chocolate Milk		*Chocolate Milk		*Chocolate Milk	
*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30	*Powdered Whole Milk	30
*Sugar	21	*Sugar	21	*Sugar	21	*Sugar	21	*Sugar	21
Cocoa	5	Cocoa	5	Cocoa	5	Cocoa	5	Cocoa	5
*Sugar	14	*Sugar	14	*Sugar	14	*Sugar	14	*Sugar	14

* Irradiated

TABLE VII

MOST RECENT VALUES AND AVERAGE CONTROL VALUES OF TESTS USED TO ASSESS POSSIBLE TOXICITY OF FOODS STERILIZED BY IONIZING RADIATION

Subject	Participated in Irradiated Food Studies	Follow-up Months After Last Irradiated Feeding	Body Weight kg.		Hemoglobin Gm./100 ml.		Hematocrit %		White Blood Cells per mm.^{3}		BSP Retention at 45 minutes		Total Serum Bilirubin Gm./100 ml.		Direct Serum Bilirubin Gm./100 ml.	
			Control	Last	Control	Last	Control	Last	Control	Last	Control	Last	Control	Last	Control	Last
MIL	I	12	72.00	68.30	15.0	15.7	47	48	6950	4700	4.1	2.5	0.4	0.6	0.05	0.10
GOE	I	12	76.64	76.05	16.4	16.7	49	46	5750	3100	9.8	7.1	0.4	0.7	0.05	0.10
PAN	I	12	78.79	77.02	13.7	14.3	45	43	5300	3800	5.5	3.0	0.1	0.5	0.00	0.10
THI	I	12	78.86	75.95	14.4	16.7	48	50	6200	6750	2.6	1.9	0.5	0.6	0.04	0.05
SMI	I	12	79.54	77.40	15.5	16.7	51	50	8100	8500	3.8	2.4	0.4	0.8	0.06	0.10
MEY	I,II,III	6	67.61	64.54	14.5	17.1	48	48	5800	10850	1.8	3.2	0.3	0.2	0.05	0.10
SIE	I,II,III	6	70.79	72.27	14.5	15.4	48	45	5000	5800	4.6	2.8	1.5	1.7	0.10	0.25
RED	I,II,III, IV	6	76.20	76.73	16.8	16.2	47	46	9400	7100	3.6	2.8	0.4	0.5	0.00	0.15
ERB	I,II,III, IV	6	78.75	73.98	14.9	16.4	47	44	7900	7000	5.8	7.6	0.6	0.3	0.05	0.07
PRE	II,III,IV	6	75.54	74.51	15.9	16.7	50	46	8800	5350	4.2	2.6	0.6	0.8	0.10	0.23
HOL	II,III,IV	6	72.39	71.51	15.7	16.9	48	51	6100	5200	3.5	4.6	0.5	0.8	0.10	0.35
LEP	II,III,IV	6	61.17	64.14	15.9	17.2	48	49	6700	6900	4.6	5.1	0.8	0.8	0.15	0.09
MAU	II,III,IV	6	69.35	69.58	16.0	17.4	48	49	5500	6000	3.8	4.0	0.8	0.4	0.17	0.07
UNR	II,III,IV	6	76.58	78.80	16.9	17.2	49	54	5400	6850	4.8	3.2	0.7	0.6	0.15	0.15
SCH	II	12	59.28	62.73	17.1	16.7	50	49	6200	8750	4.0	5.2	0.9	1.0	0.17	0.10
HEI	III,IV	6	68.23	70.89	15.6	15.9	47	48	6200	6450	3.2	3.4	0.8	0.6	0.10	0.09
PLE	IV	6	64.18	64.94	15.1	16.2	47	46	5500	5400	2.4	6.8	0.5	0.4	0.08	0.03
HUE	IV	6	59.62	62.13	14.8	16.9	46	47	7100	7700	2.5	5.8	0.6	0.2	0.11	0.07
AVERAGE			71.42	71.19	15.5	16.4	48	48	6600	6500	4.1	4.2	0.6	0.6	0.08	0.12

TABLE VII (Cont.)

MOST RECENT VALUES AND AVERAGE CONTROL VALUES OF TESTS USED TO ASSESS POSSIBLE TOXICITY OF FOODS STERILIZED BY IONIZING RADIATION

Subject	Participated in Irradiated Food Studies	Serum Protein Gm./100 ml. Control	Serum Protein Gm./100 ml. Last	Serum Albumin Gm./100 ml. Control	Serum Albumin Gm./100 ml. Last	Serum Globulin Gm./100 ml. Control	Serum Globulin Gm./100 ml. Last	Albumin/Globulin Control	Albumin/Globulin Last	Serum Alkaline Phosphatase Control	Serum Alkaline Phosphatase Last	Thymol Turbidity Control	Thymol Turbidity Last	Urinary PSP Excretion % in 15 min. Control	Urinary PSP Excretion % in 15 min. Last
MIL	I	7.9	7.9	3.8	3.8	4.1	4.1	0.9	0.9	7.9	4.7	3	3	44	38
GOE	I	7.6	7.3	4.8	4.2	2.8	3.1	1.7	1.4	6.7	3.6	2	2	48	50
PAN	I	7.7	7.3	4.0	3.9	3.7	3.4	1.1	1.1	3.9	3.2	6	10	45	54
THI	I	7.4	7.6	4.1	4.8	3.3	2.8	1.2	1.7	4.1	4.9	2	2	35	47
SMI	I	7.7	7.3	4.0	3.7	3.7	3.6	1.1	1.0	5.3	3.4	6	4	39	64
MEY	I,II,III	7.2	7.5	4.0	4.4	3.2	3.3	1.2	1.3	6.4	3.7	4	3	40	42
SIE	I,II,III	7.0	7.7	4.0	4.5	3.0	3.2	1.3	1.4	3.9	1.9	2	3	52	61
RED	I,II,III, IV	7.6	7.9	4.7	3.8	2.9	4.2	1.6	0.9	5.7	5.9	11	11	43	36
ERB	I,II,III, IV	7.2	7.1	4.1	4.7	3.1	2.4	1.3	2.0	7.1	5.8	4	2	41	48
PRE	II,III,IV	7.2	8.1	4.8	4.5	2.4	3.6	2.0	1.2	7.9	4.8	3	3	22	43
HOL	II,III,IV	7.4	7.7	4.2	4.2	3.2	3.5	1.3	1.2	7.0	5.2	3	4	28	40
LEP	II,III,IV	7.3	6.9	4.4	3.4	2.9	3.4	1.5	1.0	6.3	4.8	8	6	29	21
MAU	II,III,IV	6.7	6.8	4.7	4.5	2.0	2.3	2.4	2.0	5.8	2.7	2	1	45	40
UNR	II,III,IV	7.2	7.6	4.6	4.2	2.6	3.4	1.8	1.3	6.2	4.2	3	2	?	36
SCH	II	7.4	7.9	4.5	4.3	2.9	3.6	1.6	1.2	5.4	3.8	4	4	30	47
HEI	III,IV	7.2	6.8	4.6	3.4	2.6	3.4	1.8	1.0	3.7	5.6	2	2	38	38
PLE	IV	7.2	8.1	4.5	3.8	2.7	4.2	1.7	0.9	4.1	4.1	1	1	40	37
HUE	IV	7.1	7.3	4.2	4.2	2.9	3.1	1.4	1.4	2.8	2.2	3	4	36	43
AVERAGE		7.3	7.5	4.3	4.1	3.0	3.4	1.4	1.2	5.6	4.1	4	4	39	44

FIG. I

MEAN MONTHLY OBSERVATIONS ACCOMPANYING FOUR FIFTEEN DAY PERIODS OF FEEDING OF IRRADIATED FOOD

TEST SUBJECT RED

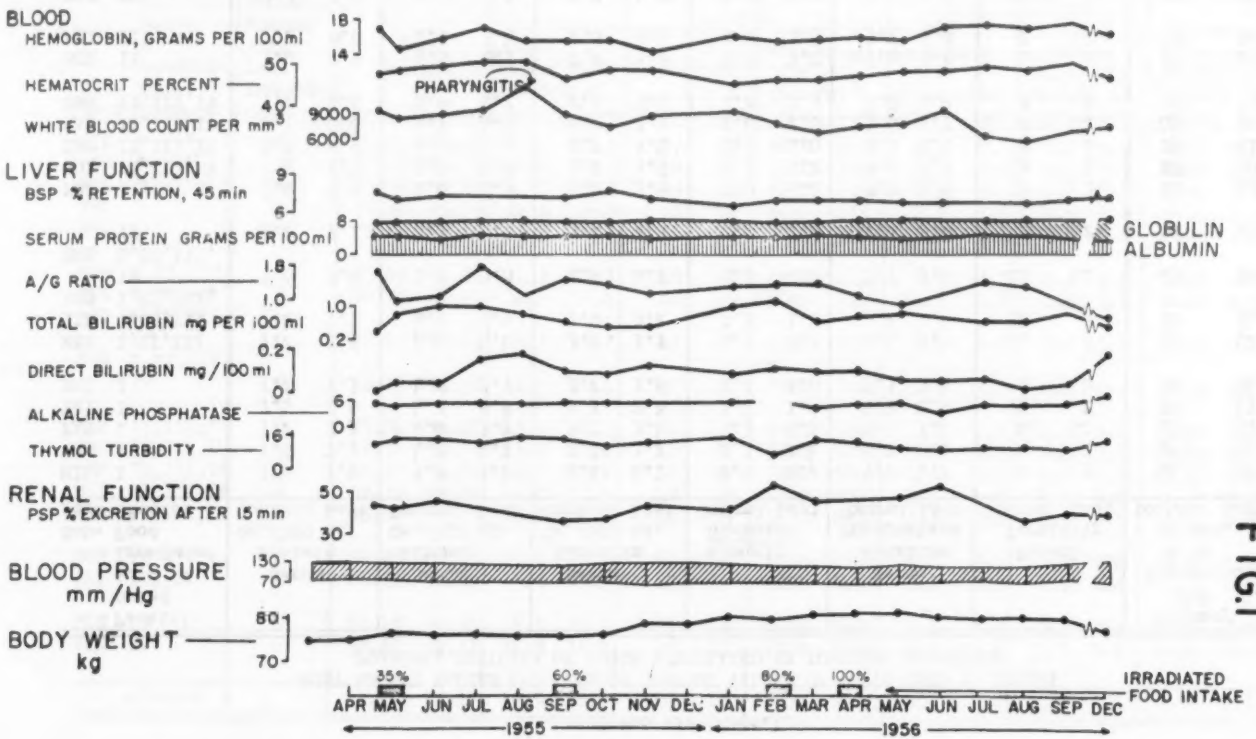

FIG. I

FIG. 2
MEAN MONTHLY OBSERVATIONS ACCOMPANYING FOUR FIFTEEN DAY PERIODS OF FEEDING OF IRRADIATED FOOD

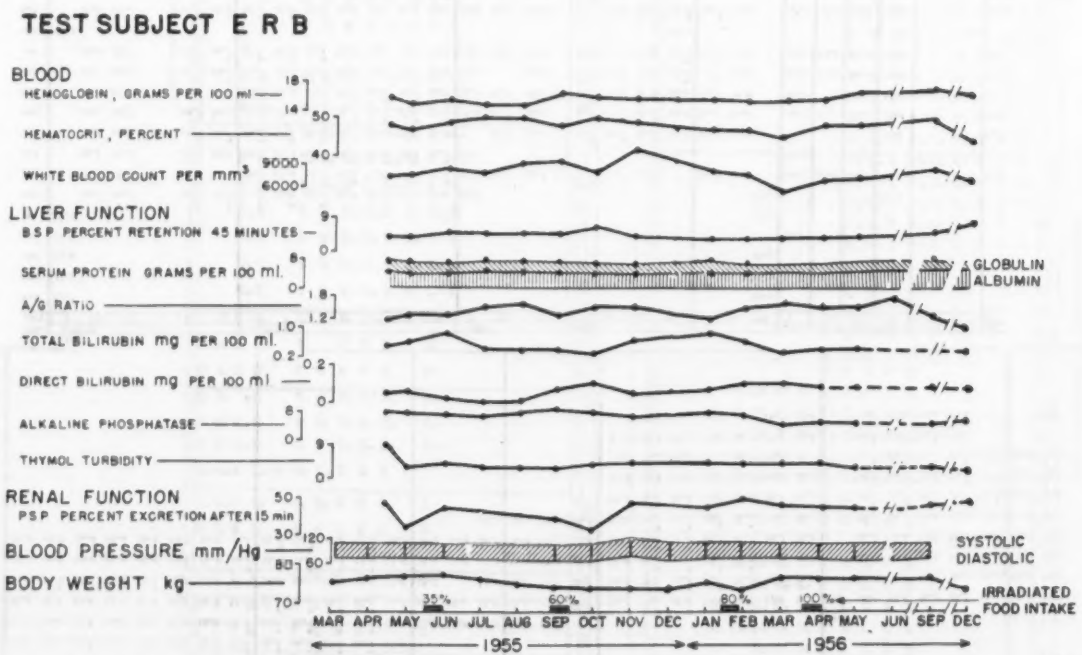

FIG. 2

APPENDIX I

GRAM HEMOGLOBIN PER 100 MILLILITERS OF INDIVIDUAL SUBJECTS TESTED

SUBJECT	1955 MAY 5	10	14	17	20	24	26	31	JUNE 3	7	10	14	17	JULY 8	19	26	AUGUST 2	9	16	SEPTEMBER 9	13	16	20	23	27	30	OCTOBER 3	5	7	11	14	17	NOVEMBER 5	28
PIL	15.0	15.8	13.8	14.6	14.6	11.8	14.6	15.0	15.2	15.0	15.2	15.4	16.0														15.0						
GOR	16.4	16.8	14.4	15.8	16.2	14.8	15.8	15.0	15.4	15.0	16.0	16.4	16.8														16.0						
PAR	13.7	13.8	11.8	13.7	14.2	12.8	13.3	13.8	13.3	13.5	13.7	13.5	14.2														13.8						
THI	15.4	15.4	13.2	13.8	15.0	13.2	14.0	12.8	14.2	14.2	15.0	14.2	15.6														15.0						
SMI	16.0	16.4	13.8	14.8	16.4	15.2	15.4	15.8	15.0	15.8	16.0	15.8	17.2	17.2	14.2	17.2	16.4	16.4									16.4						
MAT	15.4	15.4	13.2	13.7	14.0	14.2	14.8	15.4	15.0	14.4	16.4	15.6	16.8	16.8	15.4	15.8	14.4	15.6	12.8	17.7	15.4	15.0	16.0	16.3	17.0	14.1	16.6	16.5	15.4	14.7	15.4	16.3	15.7	17.8
NED	16.8	16.8	13.5	14.6	12.4	14.2	13.8	15.8	15.0	14.6	15.8	16.4	17.4	17.2		16.8	15.2	16.8	14.5	16.3	15.4	13.8	15.7	15.4	15.2	14.1		15.0		14.7	14.1	16.3	15.4	17.9
SIE	15.8	15.4	13.2	14.6	14.6	13.5	14.2	15.0	14.2	14.6	15.2	15.4	17.0	16.4	12.8	16.8	14.4	15.8	13.8	17.0	16.3		16.3	15.7	15.4	15.7		15.7	16.3	16.3	15.0	16.3	15.4	16.1
ERB	15.8	15.8	14.6	15.4	14.2	13.7	14.8	14.4	15.8	14.6	15.8	15.8	15.8	16.4	13.2	14.7	14.4	15.8	13.4	18.0	16.3	15.0	16.3	15.7	16.3	15.0		16.2	15.4	13.8	15.7	16.3	15.7	15.0
PRE																15.4	14.4	15.6	16.8	17.2	16.3	17.3	15.7	15.4	17.2	15.7		17.2	16.3	13.0	14.1	17.2	15.7	16.8
NOL																				16.3	15.7	15.4	16.3	15.7	15.0	15.7		16.3	15.4	15.4	15.0	16.3	14.5	15.4
LEP																				17.2	16.7	16.3	13.6	15.7	16.0	15.7		16.3	15.0	13.4	15.4	16.7	15.4	15.7
UNR																				17.2	17.2	18.8	15.7	15.7	16.7			17.7	16.7	14.0	14.5	17.2	15.4	11.7
SCH																				17.7	18.3	15.7	17.2	15.7	17.7	17.2		16.7	17.2	14.7	15.4	.	.	
RAU																					16.3	15.4	16.7		16.7	15.0		15.4	15.4	14.3	15.4	16.7	18.2	
NEI																																	
FLE																																	
RUE																																	

SUBJECT	1956 JANUARY 3	13	17	23	27	31	FEBRUARY 3	7	9	15	17	21	24	MAR. 1	21	28	APRIL 4	11	18	25	MAY 2	9	22	JUN. 5	JUL. 13	AUG. 8	SEPT. 6	OCT. 4	26	NOV. 10
PIL	13.8																						15.7							
GOR	15.4																						16.7							
PAR	13.6																						14.3							
THI	14.7																							16.7						
SMI	16.7																						16.7							
MAT		16.2	16.3		16.7	15.7	17.7	15.0	14.5	15.8	15.0	14.1	15.4	14.0									17.7				17.1			
RED		16.7	15.7		16.7	14.8	15.4	15.4	14.3	16.3	16.0	16.0	15.0	15.8	16.3	15.0		15.4	17.3	15.0		16.3	15.4		17.2	17.8	16.7	17.9			16.2
SIE		14.1	15.4		17.0	14.5	16.3	15.7	14.7	14.0	15.7	15.7	15.3	15.6											16.7				15.4		
ERB		16.3	16.3		15.4	14.5	14.3	15.0	14.2	15.8	16.0	15.4	15.0		14.3	16.3		15.2	16.7	14.3	15.0	16.7	16.3				17.1			16.4
PRE		15.4	16.3		16.7	14.3	16.7	15.4	15.7	14.2	15.0	15.0	13.2	15.4	15.7	15.0		15.2	17.0	14.3	15.0	16.5	14.8		16.7	17.2	17.4	18.0			16.7
NOL		16.3	17.0		16.5	16.3	16.0	15.6	14.5	14.5	14.3	15.6	15.0	15.8	15.7	15.4		15.2	15.6	15.8	14.5	16.5	15.0		17.1		17.4	17.9			16.9
LEP		15.0	15.4		15.4	14.3	15.0	15.9	15.0	14.2	16.3	15.6	15.4	15.4		15.0		15.0	16.7	15.2	17.7	16.5			17.4	16.4	16.4	17.0			17.2
UNR		13.0	18.0		18.3	16.7	16.7	15.9	16.3	16.8	15.4	16.0	15.4	14.3	15.6	14.5		15.7	16.3	15.4	15.6	18.0	15.7		17.1	17.8	17.9	17.0			17.2
SCH	14.7																				17.7								16.7	
RAU		15.0	15.4		15.7	14.3	15.8	15.6	14.2	13.8	14.3	14.8	15.7	15.0	15.4	15.4		17.0	15.0	15.0	16.7	14.3			17.1	16.2	16.4	17.9			17.4
NEI				15.7	14.3	15.7	14.3	14.2	15.4	14.2	14.0	14.8	15.0	15.0	15.4	15.4		17.0	15.8	15.0	14.7	14.3			17.1	16.5	16.4	17.9			15.9
FLE																14.5		14.5	16.3	16.3	14.0	14.1	16.7	16.7		16.1	16.8	15.1	17.4			16.2
RUE																15.4		13.8	15.7	14.5	15.0	15.7	14.1		15.8	16.8	16.9	15.2			16.9

* Commencing Irradiated Foods

APPENDIX II
HEMATOCRIT PER CENT ON INDIVIDUAL SUB-JECTS TESTED

SUB-JECT	1955 MAY 5	10	14	17	20	24	26	31	JUNE 3	7	10	14	17	21	24	28	JULY 5	19	26	AUG. 2	9	16	SEPT. 9	13	16	20	23	27	30	OCT. 3	4	7	11	14	17	21	24	28	NOV. 4	7	11	14	18	21	25	28	DEC. 2	5	9	12	16	19	23	26	30	JAN. 2	6
MIL	47	48	47	49	51	48	48	46	48	48	48	50	51																	46																												
ODE	49	50	49	48	51	50	50	48	51	51	50	52	52																	47																												
PAR	45	44	46	43	48	46	46	45	44	46	46	45	46																	42																												
TYL	47	47	50	49	49	46	49	47	48	48	48	48	49																	47																												
IPI	50	50	51	49	53	51	50	48	52	52	47	53	52	51	53	51	52	52												50																												
NEY	48	46	49	46	50	51	48	47	49	51	51	50	50	49	50	51	50	50	49	50	49	48	49	48	49	48			48	52	48	49	50	47	48																						
RED	47	48	48	46	49	49	49	47	49	50	47	50	50	51		50	48	51	51	48	48	48	48		46					46	47	48	48	49	48	49																						
HEK	48	49	48	48	48	49	48	47	49	50	50	50	51	50	50	51	48	51	50	50	48	48	48	47	48					48	47	47	46	47	46	50																						
HRB	48	48	50	49	46	43	47	48	51	50	48	50	48	51	49	50	49	51	50	50	48	47	49	48	48	49				51	50	50	48	49	50	48																						
PRE																51	50	50	51	49	48	48	48	48	48					47	46	47	48	50	47	50																						
HOL																				49	47	47	49	48		46				48	48	48	48	50	48	48																						
LEP																				50	48	48	48	46		46				48	48	48	47	46	48	49																						
URB																				50	50	51	47	48	49	48				48	48	48	48	48		50																						
SCH																				51	52	50	51	49	49	52				48	48	48	48																								
HAD																					48	48		48	49	46				48	48	48	48	48		48																						
HEI																																																																	
PLE																																																																	
HUE																																																																	
AVE.	47.7	48.8	48.4	47.6	49.0	48.1	48.3	47.0	48.9	48.0	48.6	49.5	49.9	51.0	51.0	51.2	49.5	51.3	51.2	49.7	48.2	47.7	48.1	47.6	47.8	47.7				48.6	47.6	48.7	48.6	48.7	48.8	49.0																						

SUB-JECT	1956 JAN. 2	13	17	23	27	31	FEB. 3	7	9	15	17	21	24	MAR. 3	21	28	APR. 4	11	18	25	MAY 3	9	22	JUNE 6	13	JUL. 5	AUG. 8	SEPT. 16	OCT. 5	NOV. 28	DEC. 10
MIL	46																						48								
ODE	47																						48								
PAR	45																						43								
TYL	51																							50							
IPI	53																						50								
NEY		50	49		47	50	51	46	46	47	45	46	46	48									48					48			
RED		46	45		45	44	46	45	44	48	47	48	45	47	48	44	46	49	48			44	49		48	49	48	50			46
HEK		47	46		46	46	48	48	49	48	48	48	48	48											49				46		
HRB		48	49		48	48	48	48	48	48	48	47	49		46	46	50	47	48	48		47	50					50			48
PRE		43	47		47	48	48	48	47	48	47	48	47	50	47	46	47	48	48	46		49	48		48	49	49	48			48
HOL		49	48		47	47	47	48	46	48	48	48	48	48	48	46	50	47	47	47		46	47		50		50	52			52
LEP		47	47		48	48	48	48	48	48	48	48	47	47		43	49	49	46	48		48	48		48		50	50			49
URB		48	51		48	48	48	48	48	48	48	50	48	49	49	43	48	50	47	48		47	48		49	50	51	51			50
SCH	49																			51									49		
HAD		46	46		48	48	48	48	48	46	46	47	47	48	47	45	48	48	47	48		48	48		48	48	49	52			49
HEI				46	47	50	47	46	47	48	48	47	47	48	46	48	*	48	48	46		46	49		48	47	47	52			48
PLE															47	48	48	48	48	48		48	48		47	48	46	51			46
HUE																50	47	47	43	47		48	48		48	48	48	49			47
AVE.	48.5	46.3	47.0	46.0	47.0	47.8	47.2	47.4	46.8	46.6	46.9	46.7	46.5	48.1	47.2	45.3	48.1	48.1	45.8	47.9		47.8	47.8	48.0	48.5	48.3	48.7	50.2	—	—	48.0

* Consuming irradiated foods

APPENDIX III

WHITE BLOOD COUNT PER CUBIC MILLIMETER OF INDIVIDUAL SUBJECTS TESTED

SUBJECT	1955 MAY							JUNE					JULY		AUGUST						SEPTEMBER							OCTOBER						NOVEMBER	
	9	10	14	17	20	24	25	3	7	10	14	17	9	13	20	7	9	16	2	13	16	20	23	27	30	1	4	7	11	14	17	1	28
MIL	6950	6300	5350	8700	4400	7600	7400	7600	5700	8900	7600	6000	7100													6000							
TOR	5750	4800	9100	4400	3600	4600	4700	6800	6000	5700	4550	6800	5100													9300							
PAN	5300	5350	5000	6800	3700	7000	4600	5600	5400	6500	5700	5300	5700													7600							
TAI	5500	6400	5100	7700	6700	6400	5100	4400	5700	5600	6800	5800	4700													7100							
SWI	8600	10300	6300	8300	7600	8600	7600	7600	6700	9800	8650	6400	6700	9300	10600	9600	7400	10000															
MEX	5250	6950	5500	6600	4000	5900	6200	4800	6800	6900	6500	6000	5900	7600	6100	5600	9100	8000	7800	5300	4400	6400	5750	6400	9900	5500	7200	4900	6700	5100	6500	10800	6150
VEN	9400	8800	8050	8300	7500	9800	7900	8000	11200	9300	10300	8500	6000	10800		8000	9900	13700	13700	9650	8800	11000	7400	6300	6400	10000	9000	8400	6000	7600	6300	7800	9750
SIE	4650	6050	3500	6600	4300	6100	4100	4200	6100	5800	6800	5900	5200	5600	4300	5600	6400	5800	7100	6300	6350	4200	5900	3900	4600	4500	4000	6600	6200	5600	11400	8200	6700
ESP	7300	9400	6700	8100	8000	9800	6500	5600	8300	8000	8200	8100	8900	6800	10200	6400	10000	10000	7100	10000	7700	8200	9650	7750	10600	11100	9000	7500	7000	7300	8200	10500	10750
FRE																8050	9700	8000	8400	10800	9750	8400	7350	7100	8400	8300	8800	8300	7300	5800	8600	8100	4700
ITA																				5200	5500	6300	6200	6400	5700	7600	7950	6500	5600	6500	6000	6700	8300
LIP																				6700	6100	3500	5200	5300	6300	11800	6106	6100	5400	5000	6600	5800	5350	8700
TUR																					4350	5700	6750	5150	5600	5000		6600	5100	4400	5000	5800	5300	5600
SCH																				6200	6700	6000	5400	3900	7300	8300		6200	8700	6800	6700			
CAD																					5500	7000	4800	5800	4900	5300		5700	4100	4500	6700	5000	4800	8700
SEI																																	
FLE																																	
SUE																																	

SUBJECT	1956 JANUARY						FEBRUARY							MARCH		APRIL			MAY			JUNE	JULY	AUG	SEPT	NOV	DEC
	4	13	17	23	27	31	3	7	9	15	17	24	26	5	23	6	11	18	25	3	7	22	9	11	8	6	5	26	10
MIL	4700																					4850							
ORS	3100																					5050							
PAN	3800																					3500							
TAI	6750																						6130						
SWI	8500																					7500							
MEX			6100	9800		6300	7600	600	8800	6400	1600	5700	1600	10500	5050							6550							
RED			9300	9400		7300	11300	7750	9600	8800	5900	6250	8400	7500	6600	7100	6700	7100	8600	6300			7400	7850			10850			
SIE			4650	4400		5800	5200	5800	6600	4600	5600	4400	4600	5600	5600								9130	6100	5650	6725			7100
ESP			8600	9850		6900	6700	7300	7600	5100	10000	8800	7000	7400		4300	6200						6050				5800			
FRE			5550	8000		8400	10100	8900	9100	9800	10000	7300	11000	8100	6500	8500	9000	6500	6100	7000	7150	8000	6200							
ITA			7000	7100		6000	6500	5700	7400	4600	6700	4400	6000	6300	4350	4000	6400	5800	5600	6950	5000	11250	6350							
LIP			5400	6800		6800	7300	7850	5900	6400	5200	4600	4800	6500	5000		6500	6100	6700	5800	5450	7500	5050							
TUR			6400	6850		5100	5100	6100	5900	5100	5100	6500	5000	4100	4900	6050	6000	4550	4050	3950	5400	8850	4800							
SCH	6300																				8150	5000	6250							
CAD			4400	9900		5100	4900	5900	8400	4350	5500	4700	3000	4400	7100	4000	4600	4800	4800	4600	6050	5350	4250							
SEI					8100	4600	7900	6800	4900	5000	5500	6700	8000	6800	6800	5700	7700		5800	4500	7250	7450	5700							
FLE															4900	5100		4400	6800	6300	6500	7200	5550							
SUE																	6000	9400	6800	6900	8000	7900	7200							

6150	6500	6700	5100	6400	5750	6400	9900	5500	6000	6100	6400	6600	6700	6800	6900	6500	6000	5900	7600	6100	6200	6400	6500	6600	6700	6800	6900	7000	7100	7200	7300	7400	7500	7600	7700

* Denoting Irradiated Foods

APPENDIX IV

TOTAL SERUM PROTEIN FROM INDIVIDUAL SUBJECTS TESTED

Grams per 100 milliliters of serum

1955

SUB-JECT	MAY				JUNE			JULY	AUG.		SEPT.			OCT.			NOV.		
	5	11	18	25	1	8	15	20	3	18	9	20	28	4	12	19	2	30	
MIL	7.9	7.5*	7.1*	6.7	7.2	7.0	7.7							7.1					
GOE	7.6	7.4*	7.1*	6.9	7.1	6.7	7.6							8.4					
PAN	7.7	7.4*	6.3*	6.9	6.9	6.5	7.5							7.1					
TMI	8.0	7.6	6.7	7.2	7.0*	6.7*	7.6*							7.1					
SMI	7.9	7.8	7.7	7.5	7.5*	6.9*	8.0*	8.1	8.1					7.9					
MEY	7.7	7.5	6.8	7.0	7.1*	6.7*	6.9*	7.3	7.3	7.4	7.1	7.1*	7.3	8.4	6.5	6.7	6.9	6.8	
RED	7.6	7.9*	7.1*	7.8	7.3	7.0	7.8	7.5	7.5	8.0	7.9	7.5*	7.5	7.9	7.1	7.5	7.5	7.3	
SIE	7.5	7.0	6.3	7.3	6.3*	6.3*	7.1*	6.9	7.3	7.1	6.9	6.9*	6.9	6.9	6.5	7.3	6.5	6.2	
ERD	7.9	7.3	6.7	7.1	7.1*	6.2*	6.9*	7.1	7.1	7.4	7.1	7.1*	6.9	6.5	6.8	6.7	6.5	6.2	
FRE								7.5	7.1	6.9	7.1	7.1*	6.9	7.3	6.5	6.7	6.7	6.2	
HOL											7.7	7.3	7.3	6.7*	6.7*	6.9	7.3	6.7	
LEP											7.9	6.9	7.1	7.9*	6.3*	7.3	6.7	6.7	
UNR											7.7	6.7	7.1	7.1*	6.5*	7.1	7.3	6.6	
SCH											7.1	7.7	7.5	7.3*	6.7*	7.7	7.1		
MAU													6.7	6.9*	6.3*	6.5	6.2	6.2	
NKI																			
PLE																			
HUE																			
AVE.	7.8	7.5	6.9	7.2	7.1	6.7	7.5	7.4	7.4	7.4	7.4	7.1	7.1	7.0	6.6	7.0	6.9	6.5	

1956

SUB-JECT	JAN.			FEB.				MAR.			APR.				MAY		JUNE	JULY	AUG.	OCT.		DEC.
	4	11	25	1	8	15	21	1	21	28	4	11	18	25	9	23	6	11	8	5	24	10
MIL	7.9															7.9						
GOE	7.3															7.3						
PAN	7.7															7.3						
TMI	7.1																7.6					
SMI	7.9															7.3						
MEY		7.1	7.1	6.3*	7.3*	7.7	6.5	7.1								7.5						
RED		7.5	7.9	7.1	7.1	6.3*	7.3*	7.1	7.7	7.7	8.4*	7.5*	7.7*		7.9		8.3	7.9	7.45			7.9
SIE		6.9	6.7	6.9	6.9	6.5*	6.3*	6.3												7.7		
HRD		7.9	6.9	6.7*	6.5*	6.9	6.5	7.1	6.2	6.3	6.7*	6.9*	6.7*	6.3	7.1		7.65					7.1
FRE		7.7	6.7	7.5	7.3	6.5*	6.3*	6.9	6.9	7.1	7.1*	6.9*	7.5*	6.9	7.1		7.2	7.65	7.78			8.1
HOL		7.7	7.7	7.3	7.1	6.7*	7.1*	7.3	7.1	7.1	7.5*	7.3*	7.1*	6.9	7.1		7.3		7.65			7.7
LEP		6.7	6.9	6.3*	6.8*	6.9	6.5	7.1	6.9	6.5	7.3	7.1	6.5	6.2*	6.5*		7.9	6.6	7.0			6.9
UNR		7.5	7.3	7.3*	6.9*	6.2	6.5	7.5	7.1	6.7	6.5	7.3	7.3	6.7*	7.3*		7.45	7.9	7.2			7.6
SCH	7.5													7.5							7.9	
MAU		6.5	6.2	6.5*	6.3*	6.7	6.2	6.5	6.5	6.5	6.9	6.1	6.7	6.2*	6.9*		6.9	6.7	6.6			6.8
NKI			7.1	7.3	7.1	7.1*	6.2*	7.1	7.5	6.9	7.5*	6.7*	6.3*	6.9	8.1		6.8	7.0	7.45			6.8
PLE									6.7	6.9	7.7	7.5	7.1	6.7*	7.1*		7.9	7.9	7.2			8.1
HUE									7.7		7.1	7.1	6.9	6.7*	7.5*		6.7	7.45	7.45			7.3
AVE.	7.6	7.3	7.0	7.0	6.9	6.8	6.6	7.0	7.0	6.9	7.3	7.0	7.0	6.7	7.3	7.5	7.4	7.4	7.3			7.4

*Consuming irradiated foods

APPENDIX V
GRAMS ALBUMIN PER 100 MILLILITERS SERUM ON INDIVIDUAL SUBJECTS TESTED

1955

SUBJECT	MAY				JUNE			JULY	AUG.		SEPT.			OCT.			NOV.	
	5	11	18	25	1	8	15	20	3	18	9	20	28	4	12	19	2	30
MIL	3.8	4.1*	4.2*	3.8	3.9	3.8	4.0							4.9				
GOE	4.8	4.8*	4.0*	4.2	4.5	4.3	4.3							5.0				
PAN	4.0	3.4*	3.5*	3.6	3.8	3.5	3.8							4.7				
THI	4.8	3.8	3.7	4.1	3.8*	3.8*	3.8*							3.9				
SMI	3.9	4.1	4.1	3.7	3.9*	3.8*	3.9*	5.0	4.6					4.7				
MEY	4.7	3.5	3.9	3.7	4.1*	3.7*	3.8*	4.7	4.2	4.5	4.7	4.0*	4.1	4.3	3.7	4.1	3.9	3.7
RED	4.7	3.8*	3.6*	3.6	3.6	3.7	3.7	4.7		4.1	4.4	4.0*	4.7	4.7	3.8	4.4	3.7	4.0
SIE	3.9	3.9	3.8	4.4	3.7*	3.9*	4.1*	4.3	4.3	5.0	4.9	4.1*	4.2	3.7	3.9	4.2	4.3	3.7
ERB	4.3	4.1	3.8	4.1	3.9*	3.7*	3.9*	4.3	4.3	4.7	4.6	4.1*	3.4	3.8	4.1	4.0	4.1	3.5
PRE								5.0	4.6	4.6	4.8	4.1*	4.0	4.2	3.9	4.0	4.2	3.6
HOL											4.4	4.1	4.1	3.8*	4.1*	4.0	4.2	3.7
LEP											4.7	4.0	4.4	3.9*	4.2*	4.1	3.9	3.6
UNR											5.1	4.2	4.4	4.3*	3.7*	4.3	4.2	3.8
SCH											4.2	4.7	4.5	4.4*	3.9*	3.9	3.7	
MAU													4.7	3.7*	3.9*	4.0	3.3	3.8
HEI																		
PLE																		
HUE																		
AVE.	4.3	3.9	3.8	3.9	3.9	3.8	3.9	4.7	4.4	4.6	4.6	4.1	4.3	4.3	3.9	4.1	4.0	3.7

1956

SUBJECT	JAN.			FEB.				MAR.			APR.				MAY		JUNE	JULY	AUG.	OCT.		DEC.
	4	11	25	1	8	15	21	1	21	28	4	11	18	25	9	23	6	11	8	5	24	10
MIL	4.8															3.8						
GOE	4.7															4.2						
PAN	4.7															3.9						
THI	4.6															4.8						
SMI	4.8															3.7						
MEY		4.1	4.3	4.2*	4.3*	4.3	4.4	4.2								4.4						
RED		4.2	4.4	3.8	3.9	4.1*	4.6*	4.1	3.8	4.1	4.4*	3.7*	3.7*		3.4		4.4	4.4	4.0			3.8
SIE		4.4	3.8	4.8	4.4	3.8*	3.4*	3.8									5.0			4.5		
ERB		4.2	3.7	4.0*	3.8*	4.2	4.4		3.9	4.2	3.9*	4.1*	3.9*	3.9	4.3							4.7
PRE		4.7	4.4	4.7	4.4	4.4*	4.1*	4.7	4.3	4.2	3.8*	4.4*	4.4*	4.2	4.2		3.4	4.9	4.5			4.5
HOL		4.4	4.6	4.4	4.2	4.3*	4.2*	4.7	4.1	4.2	4.7*	4.1*	4.1*	3.8	3.8		4.8		5.6			4.2
LEP		4.2	4.3	4.1*	4.2*	3.7	3.9	4.4	4.1	3.8	3.8	3.8	3.7	3.7*	3.8*		4.8	4.8	4.2			3.4
UNR		4.4	4.7	5.0*	4.6*	3.8	3.6	3.8	4.6	4.4	4.4	4.2	4.4	4.3*	4.7*		4.6	4.8	4.8			4.2
SCH	4.7													4.7							4.3	
MAU		3.6	3.7	3.8*	3.7*	4.4	3.6	3.8	4.4	4.4	4.2	4.5	4.2	4.2*	4.6*		4.6	4.6	4.2			4.5
HEI			4.8	4.8	4.1	4.4*	3.8*	4.6	3.9	4.2	4.1*	3.9*	4.2*	3.8	4.3		4.4	4.6	4.2			3.4
PLE								4.4	3.9		4.6	5.0	4.4	3.9*	4.2*		4.8	4.7	4.3			3.8
HUE								4.7			4.3	3.9	4.1	3.9*	3.8*		4.1	4.6	4.2			4.2
AVE.	4.7	4.2	4.3	4.4	4.1	4.1	4.0	4.2	4.2	4.2	4.2	4.2	4.1	4.0	4.1	4.1	4.5	4.7	4.4	-	-	4.1

*Consuming irradiated foods

APPENDIX VI

GRAMS GLOBULIN PER 100 MILLILITERS SERUM FOR INDIVIDUAL SUBJECTS TESTED

1955

SUB-JECT	MAY 5	11	18	25	JUNE 1	8	15	JULY 20	AUG. 3	18	SEPT. 9	20	28	OCT. 4	12	19	NOV. 2	30
MIL	4.1	3.4	2.9*	2.9	3.3	3.2	3.7							2.2				
OOR	2.8	2.8*	3.1*	2.7	2.6	2.4	3.3							3.4				
PAN	3.7	4.0*	2.8*	3.3	3.1	3.0	3.7							2.4				
THI	3.2	3.8	3.0	3.1	3.4*	2.9*	3.8*							3.2				
SMI	4.0	3.7	3.6	3.8	3.8*	3.1*	4.1*	3.1	3.5					3.2				
MET	3.0	4.0	2.9	3.3	3.0*	3.0*	3.1*	2.6	3.1	2.9	2.4	3.1*	3.2	4.1	2.8	2.6	3.0	3.1
RED	3.9	4.1*	3.5*	4.2	3.7	3.3	4.1	2.8	2.9	3.9	3.5	3.5*	2.8	3.5	3.3	3.1	3.8	3.3
SIE	3.6	3.1	2.5	2.9	2.6*	2.4*	3.0*	2.6	3.0	2.1	2.0	2.8*	2.7	3.2	2.6	3.1	2.2	2.5
ERB	3.6	3.2	2.9	3.0	3.2*	2.5*	3.0*	2.8	2.8	2.7	2.5	3.0*	3.5	2.7	2.7	2.7	2.4	2.7
PRE								2.5	2.5	2.3	2.3	3.0*	2.9	3.1	2.6	2.7	2.5	2.6
HOL											3.3	3.2	3.2	3.1*	2.6*	2.9	3.1	3.0
LEP											3.2	2.9	2.7	4.0*	2.1*	3.2	2.8	3.1
UNR											2.6	2.5	2.7	2.8*	2.8*	2.8	3.1	2.8
SCH											2.9	3.0	3.0	2.9*	2.8*	3.8	3.4	
MAU													2.0	3.2*	2.4*	2.5	2.9	2.4
HEI																		
PLE																		
HUE																		
AVE.	3.5	3.6	3.0	3.2	3.2	2.9	3.5	2.7	3.0	2.8	2.7	3.0	2.8	3.1	2.7	2.9	2.9	2.8

1956

SUB-JECT	JAN. 4	11	25	FEB. 1	8	15	21	MAR. 1	21	28	APR. 4	11	18	25	MAY 9	23	JUNE 6	JULY 11	AUG. 8	SEPT. 5	OCT. 5	24	DEC. 10
MIL	3.1															4.1							
OOR	2.6															3.1							
PAN	3.0															3.4							
THI	2.5																2.8						
SMI	3.1															3.6							
MET		3.0	2.8	2.7*	3.0*	3.4	2.1	2.9								3.1				4.6			
RED		3.3	3.5	3.3	3.2	2.7*	2.9*	3.0	3.9	3.6	4.0*	3.8*	4.0*		4.5		3.9	3.5	3.4	4.5			4.2
SIE		2.5	2.9	2.1	2.5	2.7*	2.9*	2.5														3.2	
ERB		3.7	3.2	2.7*	2.9*	2.7	2.1		2.3	2.1	2.8*	2.8*	2.8*	2.4	2.8		2.7			3.2			2.4
PRE		3.0	2.3	2.8	2.9	2.1*	2.2*	2.2	2.6	2.9	3.3*	2.5*	3.1*	2.7	2.9		3.8	2.8	3.2	4.4			3.6
HOL		3.3	3.1	2.9	2.9	2.4*	2.9*	3.6	3.0	2.9	2.8*	3.2*	3.0*	3.1	3.3		2.5		2.1	4.4			3.5
LEP		2.7	2.6	2.2*	2.7*	3.2	2.6	2.7	2.8	2.7	3.5	3.3	2.8	2.5*	2.7		3.0	1.8	2.8	4.2			3.4
UNR		3.1	2.6	2.3*	2.3*	2.4	2.9	2.7	2.5	2.3	2.1	3.1	2.9	2.8*	2.8		2.8	3.1	2.4	3.05			3.4
SCH	2.8													2.8								3.6	
MAU		2.9	2.5	2.7*	2.8*	2.3	2.6	2.7	2.1	2.1	2.7	1.6	2.5	2.8*	2.3*		2.2	2.1	2.4	3.1			2.3
HEI			2.3	2.5	3.0	2.7*	2.4*	2.5	3.6	2.7	3.4*	2.8*	2.7*	3.1	3.8		2.4	2.4	3.3	4.3			3.4
PLE								2.3	3.0		3.1	2.5	2.7	2.8*	2.9*		3.1	3.2	2.9	3.6			4.2
HUE								3.0			2.8	3.2	2.8	2.8*	3.7		2.6	2.8	3.3	4.0			3.1
AVE.	2.8	3.1	2.8	2.6	2.8	2.7	2.6	2.8	2.8	2.7	3.1	2.9	2.9	2.6	3.1	3.4	2.9	2.7	2.9	3.9			3.4

*Consuming irradiated foods

APPENDIX VII

SERUM ALBUMIN-GLOBULIN RATIO ON INDIVIDUAL SUBJECTS TESTED

1955

SUB-JECT	MAY				JUNE			JULY	AUG.		SEPT.			OCT.			NOV.		
	5	11	18	25	1	8	15	20	3	18	9	20	28	4	12	19	2	30	
MIL	0.93	1.20	1.45*	1.31	1.18	1.19	1.08							2.20					
GOE	1.70	1.64*	1.29*	1.56	1.73	1.79	1.30							1.50					
PAN	1.08	0.85*	1.25*	1.09	1.22	1.17	1.03							2.00					
THI	1.50	1.00	1.23	1.32	1.06*	1.31*	1.00*							1.20					
SMI	0.97	1.11	1.58	0.97	1.08*	1.23*	0.95*	1.60	1.30	2.00				1.50					
MEY	1.56	0.88	1.14	1.12	1.37*	1.23*	1.23*	1.80	1.40	1.50	2.00	1.30*	1.30	1.10	1.30	1.60	1.30	1.20	
RED	1.60	0.93*	1.03*	0.86	0.98	1.18	0.90	1.70	1.60	1.10	1.30	1.15*	1.70	1.30	1.20	1.40	1.00	1.20	
BIE	1.08	1.26	1.52	1.52	1.42*	1.42*	1.37*	1.30	1.40	2.40	2.40	1.40*	1.50	1.20	1.50	1.50	2.00	1.50	
KRB	1.20	1.28	1.31	1.37	1.28*	1.48*	1.30*	1.60	1.50	1.80	1.80	1.40*	1.00	1.40	1.50	1.50	1.70	1.30	
PRE								2.00	1.80	2.00	2.00	1.40*	1.40	1.40	1.50	1.50	1.70	1.40	
HOL											1.30	1.30	1.30*	1.20*	1.60	1.40	1.40	1.20	
LEP											1.50	1.40	1.60*	1.00*	2.00	1.30	1.40	1.20	
UNR											2.00	1.70	1.60*	1.50*	1.30	1.50	1.40	1.40	
SCH											1.40	1.60	1.50*	1.50*	1.40	1.00	1.10		
MAU													2.30*	1.20*	1.60	1.60	1.10	1.60	
HEI																			
PLE																			
HUE																			

1956

SUB-JECT	JAN.			FEB.				MAR.			APR.				MAY	JUNE	JULY	AUG.	SEPT.	OCT.		DEC.
	4	11	25	1	8	15	21	1	21	28	4	11	18	25	9	23	6	11	8	5	5	24	10
MIL	1.60														0.93								
GOE	1.80														1.40								
PAN	1.60														1.10								
THI	1.40																1.70						
SMI	1.60														1.00								
MEY		1.40	1.50	1.60*	1.40*	1.30	2.10	1.40							1.40					0.90			
RED		1.30	1.30	1.20	1.20	1.50*	1.60*	1.40	1.00	1.20	1.10*	1.00*	0.93*		0.80		1.10	1.30	1.16	1.00			0.9
BIE		1.80	1.30	2.30	1.80	1.40*	1.20*	1.50									1.80				1.4		
KRB		1.10	1.20	1.50*	1.20*	1.50	2.10		1.70	2.00	1.40*	1.50*	1.40*	1.60*	1.50					1.80			2.0
PRE		1.60	1.80	1.70	1.50	2.10*	1.90*	2.10	1.60	1.50	1.20*	1.80*	1.40*	1.60*	1.40		0.90	1.80	1.37	1.20			1.2
HOL		1.30	1.50	1.50	1.40	1.80*	1.40*	1.40	1.40	1.50	1.70*	1.30*	1.40*	1.20*	1.10		1.90		2.64	1.10			1.2
LEP		1.50	1.70	1.90*	1.60*	1.80	1.50	1.60	1.50	1.40	1.10	1.20	1.30	1.50*	1.40*		1.60	2.70	1.48	1.18			1.0
UNR		1.40	1.80	2.20*	2.00*	1.40	1.20	1.40	1.80	1.90	2.10	1.40	1.50	1.90*	1.80*		1.70	1.60	2.00	1.70			1.3
SCH	1.80													1.70									
MAU		1.20	1.50	1.40*	1.40*	1.80	1.40	1.40	2.10	2.10	1.60	2.80	1.70	2.10*	2.00*		2.10	2.20	1.81	1.80			2.0
HEI			2.10	1.90	1.40	1.60*	1.60*	1.80	1.10	1.60	1.20*	1.40*	1.60*	1.20*	1.10		1.90	1.90	1.28	1.07			1.0
PLE								1.90	1.30		1.50	2.00	1.60	1.40*	1.40*		1.50	1.50	1.50	1.60			0.9
HUE								1.60			1.50	1.20	1.50	1.40*	1.00*		1.60	1.30	1.28	1.19			1.4

*Consuming irradiated foods

APPENDIX VIII
ALKALINE PHOSPHATASE FROM INDIVIDUAL SUBJECTS TESTED
Shinowara Units

SUBJECT	1955 MAY 5	MAY 11	MAY 18	MAY 25	JUNE 1	JUNE 8	JUNE 15	JULY 20	AUG. 3	AUG. 18	SEPT. 9	SEPT. 20	SEPT. 28	OCT. 4	OCT. 12	OCT. 19	NOV. 2	NOV. 30
MIL	7.9	7.3*	6.0*	6.8	6.9	7.1	7.4							8.4				
COE	6.7	4.5*	4.9*	4.2	4.5	4.5	4.1							4.9				
PAN	3.9	3.8*	3.4*	4.4	3.7	4.1	3.9							5.9				
THI	5.3	4.3	1.9	5.0	4.4*	4.5*								5.1				
SMI	5.8	5.3	4.4	5.6	5.9*	5.4*	5.2*	5.4	4.6					4.9				
MEY	7.2	5.2	5.8	7.2	7.8*	6.4*	6.8*	6.5	7.6	7.3	6.8	6.7*	7.2	7.2	6.9	6.7	7.4	5.8
REO	5.7	8.8*	2.1*	5.7	5.4	5.3	4.5	5.3	6.2	4.3	5.3	3.8*	6.8	7.5	4.2	4.9	6.1	3.9
SIE	3.9	3.9	3.6	4.3	4.0*	3.8*	4.0*	4.2	4.5	4.6	3.9	4.7*	6.9	4.9	4.1	3.3	4.3	4.3
ERB	7.3	7.1	6.2	7.9	7.1*	6.5*	6.8*	6.3	7.2	8.1	8.3	9.0*	8.0	8.2	6.0	7.3	6.5	5.5
PRE								7.2	8.0	7.7	8.7	9.0*	10.3	12.1	9.7	9.2	8.6	4.8
HOL											7.0	6.0	7.9	8.4*	6.7*	9.3	7.5	4.8
LEP											5.6	5.2	8.2	5.4*	4.1*	4.8	4.9	4.0
UNR											5.6	6.0	7.1	5.9*	4.3*	5.9	6.1	6.0
SCH											5.1	5.2	6.0	5.1*	4.1*	5.0	5.1	
MAU												5.4	5.2	6.0*	4.4*	6.5	5.2	5.0
NEI																		
PLE																		
HUE																		
AVE.	6.0	5.3	4.3	5.7	5.5	5.2	5.3	5.8	6.4	6.4	6.3	6.1	7.5	6.7	5.4	6.3	6.2	4.9

SUBJECT	1956 JAN. 4	JAN. 11	JAN. 25	FEB. 1	FEB. 8	FEB. 15	FEB. 21	MAR. 1	MAR. 21	MAR. 28	APR. 4	APR. 11	APR. 18	APR. 25	MAY 9	MAY 23	JUNE 6	JULY 11	AUG. 8	SEPT. 5	OCT. 5	OCT. 24	DEC. 10
MIL	6.9															4.7							
COE	4.4															3.6							
PAN	5.4															3.2							
THI	3.9																4.9						
SMI	5.4															3.4							
MEY		3.5	5.8	6.4*	5.4*	6.7	4.4	6.2								3.3				3.7			
REO		5.4	5.0	4.9	6.5	6.0*	4.4*	3.9	4.3	3.3	4.1*	4.3*	4.5*		4.8		2.2	4.2	3.8	4.1			5.9
SIE		5.5	3.7	4.6	5.3	5.8*	5.1*	3.1									2.6				1.9		
ERB		6.7	8.0	6.7*	6.8*	7.9	4.9	4.1	4.1	3.9	4.4*	5.1*	5.4*	4.4	4.6					4.0			5.8
PRE		7.5	8.0	9.0	9.6	7.9*	5.4*	6.5	5.2	4.1	5.1*	6.0*	5.8*	6.7	5.9		3.6	4.6	3.6	4.9			4.8
HOL		6.0	8.2	9.0	9.7	10.0*	6.8*	7.1	5.9	4.4	6.2*	5.4*	5.9*	6.5	6.2		5.2			6.3			5.2
LEP		3.9	4.6	5.2*	5.3*	5.1	3.9	4.3	4.3	5.1	4.8	5.3	4.7	4.4*	4.0*		3.2	3.8	3.0	4.0			4.8
UNR		5.1	5.8	5.1*	5.1*	6.7	6.2	4.1	3.8	3.0	4.3	7.2	5.0	4.8*	4.9*		5.8	4.6	3.6	3.7			4.2
SCH	4.2													3.5								3.8	
MAU		4.6	5.3	5.2*	6.2*	4.6	3.9	4.4	3.6	2.9	4.2	4.3	4.4	4.8*	4.8*		2.8	4.1	2.9	3.4			2.7
NEI			3.6	4.6	3.0	3.8*	2.1*	3.0	2.7	1.2	3.1*	2.8*	2.5*	2.9	2.7		8.4	2.8	2.7	2.8			5.6
PLE									4.8	2.8	4.0	4.3	4.7	4.8*	4.8*		5.3	4.5	2.8	3.7			4.1
HUE									2.1		2.8	3.5	2.6	2.2	2.1*		2.4	2.5	3.8	2.2			
AVE.	5.0	5.4	5.8	6.1	6.3	6.4	4.7	4.7	4.1	3.4	4.3	4.8	4.6	4.4	4.4	3.6	4.2	3.9	3.0	3.9	-	-	4.3

*Consuming irradiated foods

APPENDIX II
THYMOL TURBIDITY MEAN INDIVIDUAL SUBJECTS TESTED
MacLagan Units

1955

SUBJECT	MAY 5	11	18	25	JUN 1	8	15	JUL 20	AUG 3	18	SEP 9	20	26	OCT 4	12	19	NOV 2	30
MIL	3	*2	*3	3	2	3	3							2				
GOE	2	*2	*2	3	2	3	3							2				
PAN	6	*6	*6	6	6	6	6							6				
TAI	2	1	1	2	*2	*4	*2							4				
SMI	5	5	7	6	*6	*8	*8	6	7					8				
MEY	5	3	3	4	*4	*4	*4	3	3		4	*3	3	3	4	4	5	3
RED	11	*16	*12	15	13	14	14	12	15		18	*15	10	10	10	9	13	11
SIE	2	1	2	2	*1	*3	*2	1	2		2	*2	2	2	2	2	2	1
ERB	6	3	2	4	*5	*4	4	3	3		4	*3	2	4	4	3	4	3
FRE								2	3		3	*3	3	4	2	3	5	3
MOL											4	3	3	*2	*2	4	3	3
LEP											8	8	8	*8	*8	7	8	6
UNR											3	2	3	*2	*2	2	3	2
SCH											3	4	4	*3	*3	3	3	
MAU												2	2	*1	*1	1	2	2
HEI																		
FLE																		
HUE																		
AVE.	4	3	3	4	4	4	4	3	4		4	3	3	3	3	3	4	3

1956

SUBJECT	JAN 4	11	25	FEB 1	8	15	21	MAR 1	21	28	APR 4	11	18	25	MAY 9	23	JUN 6	JUL 11	AUG 8	SEP 5	OCT 5	24	DEC 10
MIL	2														3								
GOE	1														2								
PAN	7														10								
TAI	1														2								
SMI	5														4								
MEY		3	3	*3	*3	10	2	4							3								
RED		15	12	7	5	*3	*9	9	18	10	*10	*13	*14		9		7	8	8	7			11
SIE		1	1	2	1	*2	*1	2									1				3		
ERB		4	5	*3	*2	4	7	4	6	3	*3	*4	*4	6	3					3			2
FRE		5	3	3	2	*2	*1	3	3	3	*3	*1	*3	2	2		2	4	1	4			3
MOL		2	3	2	2	*2	*2	3	3	3	*3	*3	*3	3	2		1		2	2			4
LEP		7	6	*7	*6	2	6	8	7	5	6	6	7	*8	*6		5	6	5	7			6
UNR		2	3	*3	*3	6	2	3	4	2	2	2	4	*3	*2		1	4	2	2			2
SCH	2													3								4	
MAU		1	2	*2	*1	1	2	1	2	2	2	2	2	*2	*1		2	2	1	1			1
HEI			3	2	2	*3	*1	2	2	2	*2	*2	*2	2	1		1	2	1	2			2
FLE									1	1	1	2	2	*1	*1		2	1	0	1			1
HUE									3		2	4	3	*4	*2		2	3	1	2			4
AVE.	3	3	3	3	2	4	3	3	3	3	3	3	3	4	2	4	2	3	2	3			3

(Excluding subject RED)

*Consuming irradiated food

APPENDIX X

TOTAL BILIRUBIN FROM INDIVIDUAL SUBJECTS TESTED

mg per 100 ml serum

1955

SUBJECT	MAY				JUN			JUL	AUG		SEP			OCT			NOV	
	5	11	18	25	1	8	15	20	3	18	9	20	26	4	12	19	2	30
MIL	0.40	0.40	0.60	0.30	0.20	0.30	0.70							0.20				
GOE	0.40	0.90	0.10	1.00	0.70	0.60	0.90							0.30				
FAN	0.10	0.85	0.55	0.60	0.20	0.50	0.50							0.10				
THI	0.60	0.40	0.80	0.30	0.60	0.20	0.90							0.30				
SMI	0.30	0.50	0.40	0.50	0.30	0.80	0.80	0.30	0.70					0.50				
MEY	0.10	0.25	0.60	0.40	0.30	0.30	0.50	0.40	0.60	0.50	1.20	0.40	0.40	0.30	0.60	0.70	0.30	0.50
RED	0.40	0.80	0.80	0.70	1.10	4.10	0.80	1.00	0.80	0.90	0.30	0.80	0.60	0.50	0.80	0.30	0.80	0.80
SIE	1.40	1.05	1.60	2.00	1.40	1.10	1.80	1.30	1.40	1.70	1.00	1.80	1.70	1.30	1.60	1.60	1.90	1.90
KRB	0.50	0.80	0.60	0.30	0.80	0.80		0.40	0.30	0.40	0.30	0.40	0.60	0.30	0.40	0.30	0.60	0.60
PHE								1.10	0.70	0.30	0.40	0.60	0.40	0.40	0.70	0.20	0.60	0.30
HOL											0.20	0.60	0.70	0.60	0.60	0.30	0.50	0.70
LEP											1.00	0.80	0.60	0.40	1.10	0.80	0.80	0.70
UNR											0.80	0.80	0.50	0.30	0.80	1.40	0.70	0.90
SCH											0.80	0.90	1.00	0.50	0.80	0.30	1.10	
MAU												1.2	0.30	0.30	1.10	0.70	0.70	0.90
HKI																		
FLE																		
HUB																		
AVE.	0.5	0.7	0.7	0.7	0.6	0.64	0.8	0.8	0.8	0.8	0.7	0.8	0.7	0.4	0.8	0.7	0.7	0.8

1956

SUBJECT	JAN			FEB				MAR			APR				MAY		JUN		JUL	AUG	SEP	OCT		DEC
	4	11	25	1	8	15	21	1	21	28	4	11	18	25	9	23	6	13	8	5	5	24	10
MIL	0.60															0.60							
GOE	0.40															0.70							
FAN	0.70															0.50							
THI	0.40																0.65						
SMI	0.50															0.80							
MEY		0.70	0.60	0.50	0.60	0.80	0.60	0.50								0.70				0.20			
RED		0.80	1.20	1.50	0.90	0.90	1.00	0.70	0.70	0.30	0.60	0.60	0.80		0.80		1.25	0.60	0.60	0.80			0.47
SIE		1.60	2.00	1.90	1.70	1.00	1.70	1.20									1.80				1.70		
KRB		0.80	0.80	0.50	0.70	0.80	0.60	0.40	0.40	0.20	0.80	0.30	0.50	0.40	0.40					1.55			0.28
PHE		0.80	0.40	0.90	0.80	0.90	0.60	0.50	0.60	0.40	0.80	0.30	0.80	0.40	1.00		1.15	0.90	0.75	0.95			0.85
HOL		0.50	0.60	0.90	0.80	1.00	0.60	0.80	0.80	0.30	0.50	0.40	0.70	0.30	0.70		0.65		0.60				0.75
LEP		1.10	1.00	0.70	1.00	1.20	0.80	0.60	0.60	0.70	0.60	0.60	0.80	0.60	1.10		1.00	1.00	1.05	0.70			0.80
UNR		0.50	0.60	0.80	0.80	1.10	0.70	0.70	0.80	0.50	0.70	0.50	0.80	0.60	1.00		1.50	1.10	0.80	0.80			0.65
SCH	0.50													0.50									
MAU		1.00	0.80	1.10	0.90	1.90	0.80	1.30	0.90	0.50	0.80	0.60	0.80	0.60	1.20		0.80	0.40	0.40	0.40		1.00	
HKI			0.90	0.70	0.80	0.70	0.70	0.60	0.60	0.60	0.90	0.40	0.80	0.50	0.90		1.35	0.90	0.70	1.10			0.35
FLE								0.40	0.50		0.60	0.40	0.50	0.40	0.90		0.40	0.40	0.40	1.50			0.62
HUB								0.60			0.80	0.20	0.80	0.50	1.00		1.20	0.85	0.45				0.45
AVE.	0.5	0.7	0.9	1.0	0.9	1.0	0.8	0.7	0.6	0.4	0.6	0.4	0.7	0.5	0.9	0.7	1.1	0.8	0.6	0.74			0.35
																							0.54

* Value omitted from average

† Consuming irradiated food

APPENDIX XI

SERUM DIRECT BILIRUBIN FROM INDIVIDUAL SUBJECTS TESTED

mg per 100 ml

1955

SUBJECT	MAY 5	MAY 11	MAY 18	MAY 25	JUN 1	JUN 8	JUN 15	JUL 20	AUG 3	AUG 18	SEP 9	SEP 20	SEP 28	OCT 4	OCT 12	OCT 19	NOV 2	NOV 30	
MIL	0.05	0.05*	0.05*	0.05	0.00	0.05	0.05							0.10					
GOE	0.05	0.07*	0.05*	0.08	0.05	0.10	0.05							0.15					
PAN	0.00	0.00*	0.00*	0.10	1.05	0.00	0.05							0.05					
THI	0.05	0.00	0.08	0.05	0.05*	0.05*	0.05*							0.01					
SMI	0.05	0.05	0.05	0.10	0.05*	0.05*	0.00*	0.00	0.15					0.10					
MET	0.05	0.00	0.05	0.10	0.05*	0.00*	0.00*	0.10	0.10	0.15	0.15	0.10*	0.05	0.10	0.10	0.20	0.05	0.05	
RED	0.00	0.05*	0.05*	0.05	0.08	0.00	0.05	0.15	0.20	0.15	0.10	0.15*	0.05	0.00	0.15	0.10	0.10	0.15	
SIE	0.08	0.12	0.08	0.15	0.01*	0.05*	0.08*	0.20	0.25	0.15	0.15	0.25*	0.30	0.15	0.15	0.30	0.15	0.30	
KNE	0.05	0.07	0.05	0.05	0.00*	0.00*	0.05*	0.00	0.00	0.15	0.10	0.05*	0.05	0.10	0.10	0.10	0.05		
PRE								0.15	0.10	0.05	0.10	0.10*	0.00	0.00	0.10	0.10	0.10	0.05	
HOL											0.10	0.15	0.05	0.10*	0.10*	0.05	0.10	0.05	
LEP											0.15	0.15	0.15	0.05*	0.15*	0.10	0.05	0.10	
UNR											0.30	0.15	0.10	0.05*	0.10*	0.30	0.05	0.20	
SCH											0.15	0.15	0.20	0.15*	0.15*	0.10	0.05		
MAU												0.30	0.05	0.10*	0.15*	0.25	0.10	0.10	
MEI																			
PLE																			
HUE																			
AVE.	0.04	0.05	0.05	0.08	0.15	0.03	0.04	0.10	0.13	0.13	0.13	0.10	0.10	0.08	0.12	0.16	0.08	0.12	

1956

SUBJECT	JAN 4	JAN 11	JAN 25	FEB 1	FEB 8	FEB 15	FEB 21	MAR 1	MAR 21	MAR 28	APR 4	APR 11	APR 18	APR 25	MAY 9	MAY 23	JUN 6	JUN 13	AUG 8	SEP 5	OCT 5	OCT 24	DEC 30	
MIL	0.05														0.1									
GOE	0.10														0.1									
PAN	0.05														0.1									
THI	0.10																0.05							
SMI	0.1														0.1									
MET		0.05	0.05	0.10*	0.05*	0.10	0.05	0.10							0.1					0.1				
RED		0.05	0.10	0.10	0.10	0.10*	0.10*	0.10	0.05	0.10	0.10*	0.10*	0.10*		0.05		0.05	0.05	0.00	0.02			0.15	
SIE		0.15	0.20	0.15	0.10	0.10*	0.10*	0.05									0.1				0.25			
KNE	0.05	0.10	0.05	0.10*	0.15*	0.10	0.05	0.05	0.10	0.15	0.05*	0.05*	0.10*	0.10						0.3			0.07	
PRE		0.05	0.10	0.10	0.10	0.10*	0.15*	0.10	0.05	0.10	0.10*	0.10*	0.10*	0.10	0.10		0.2	0.05	0.12	0.15			0.23	
HOL		0.05	0.10	0.10	0.15	0.10*	0.10*	0.10	0.05	0.15	0.10*	0.10*	0.10*	0.10	0.10		0.10		0.10	0.20			0.35	
LEP		0.10	0.10	0.10*	0.10*	0.10	0.10*	0.10	0.05	0.10	0.10	0.05	0.10	0.10*	0.20		0.10	0.10	0.15	0.60			0.09	
UNR		0.10	0.05	0.10*	0.10*	0.10	0.10*	0.10	0.05	0.10	0.10	0.10	0.10	0.10*	0.15		0.10	0.20	0.08	0.20			0.15	
SCH	0.05													0.10							0.1			
MAU		0.05	0.10	0.10*	0.10*	0.10*	0.10*	0.10	0.05	0.10	0.10	0.05	0.10	0.10*	0.10*		0.10	0.05	0.05	0.20			0.07	
MEI			0.10	0.10	0.10	0.10*	0.10*	0.10	0.05	0.10	0.10*	0.10*	0.10*	0.10	0.10		0.10	0.12	0.12	0.35			0.09	
PLE								0.05	0.15	0.10	0.05	0.05	0.10*	0.10*			0.00	0.00	0.05	0.60			0.03	
HUE								0.20	0.10	0.05	0.10	0.10	0.10	0.10*										
AVE.	0.07	0.08	0.10	0.11	0.11	0.11	0.10	0.09	0.07	0.12	0.09	0.08	0.10	0.10	0.11	0.1	0.07	0.08	0.08	0.27			0.07	0.13

*Consuming irradiated food

APPENDIX XII

PERCENTAGE RETENTION OF BROMSULPHALEIN AFTER 45 MINUTES BY INDIVIDUAL SUBJECTS TESTED

	1955								1956																							
SUBJECT	MAY		JUNE	SEPT.		OCT.		NOV.		JAN.			FEB.	MAR		APR.			MAY		JUNE	JULY	AUG.	SEPT.	OCT.		DEC.
	5	25	15	9	28	4	19	2	30	4	11	25	1	1	21	4	18	25	9	23	6	11	6	6	5	24	10
MIL	4.1	2.7*	4.0			2.5				3.0										2.5												
GOE	9.8	6.3*	7.0			6.5				6.2										7.1												
PAN	5.5	4.8*	4.8			4.2				6.2										3.0												
THI	3.0	2.3	0.0*			3.5				3.5											1.9											
SMI	4.0	3.5	3.6*			4.8				4.0										2.4												
MEY	2.3	1.2	1.8*	2.0	2.7*		3.5	2.5	1.6		1.8		1.4*	1.8						1.4				3.2								
RED	4.5	2.4*	3.4	3.5	2.5*		4.2	3.5	2.0		1.4		2.8	3.0*	2.3	1.8*	2.8*		2.0		1.8	9.8	1.9	2.3			2.8
SIE	4.8	4.5	4.8*	4.2	4.0*		7.0	4.8	7.1		5.5		4.3*	3.0							3.6				2.8		
ERB	7.9	3.7	4.6*	4.2	4.2*		6.0	4.0	3.7		3.2		3.2	4.3*	3.0	3.0*	4.3*		3.2					4.15			7.6
PRE				4.2	2.7*		7.0	4.0	3.0		3.2		2.8	3.5*	3.0	2.0*	4.3*		2.3		2.8	7.6	2.0	2.5			2.6
HOL				3.3	3.7		5.5*	3.5	3.7		2.5		2.5	1.2*	2.5	3.2*	3.0*		2.8		1.8			4.0			4.6
LEP				5.5	3.7		6.0*	4.0	3.0		4.0		3.2*	2.0	3.5	2.8	3.7		2.8*		3.0	4.7	2.9	4.7			5.1
UNR				5.5	4.0		5.0*	10.5	8.4		11.1		4.8*	5.5	4.3	4.0	5.7		4.3*		4.2	3.7	5.3	5.7			3.2
SCH				4.8	3.3		4.2*	4.5			3.0							3.0								5.2	
MAU				3.3	4.3		4.5*	3.7	2.5		2.3		3.0*	2.3	2.0	2.8	3.7		2.0*		2.1	0.8	3.7	2.5			4.0
HEI												4.0	2.3	2.8*	2.5	2.0*	3.0*		2.5		1.2	1.7	2.1	2.0			3.4
PLE															2.5	2.3	2.5		1.6*		1.5	2.3	2.7	1.6			6.8
HUE															3.0	2.0	2.5		1.8*		2.9	4.8	2.6	2.3			5.8
AVE.	5.1	3.5	3.7	3.8	3.5	4.3	5.3	4.5	3.9	4.6	3.8	4.0	3.0	2.9	2.9	2.6	3.6	3.0	2.5	3.2	2.4	4.4	2.9	3.2	-	-	4.6

*Consuming irradiated foods

52249 O—60—pt. 2——10

APPENDIX XIII

CUMULATIVE PRIMARY REJECTION OF PBP[oo] DYE BY INDIVIDUAL SUBJECTS TESTED

1955

SUBJECT	FAT 6				FAT 24				JUNE 46				SEPT 8				SEPT 27				OCT 4				OCT 20				NOV 3				NOV 28			
	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120
WIL	44	56	70	80	42	55	74	83*	38	56	68	76									47	66	80	87												
COE	48	66	84	95	46	68	87	101*	37	62	79	90									50	75	95	108												
PAN	45	55	70	80	43	60	78	87*	37	53	67	75									38	58	75	85												
TRI	29	53	73	86	42	57	68	77	36	56	73	84*									18	45	66	80												
SMI	37	61	80	93	42	60	79	91	39	58	75	87*									43	72	82	104												
MET	42	60	79	94	39	60	79	93	38	56	74	87*	71	55	63	71	29	51	69	81*					22	40	61	75	35	62	85	99	38	58	88	106
RED	43	59	80	96	43	60	78	90*	45	67	87	101	33	53	73	85	27	58	78	91*					36	54	72	84	40	63	83	97	44	66	86	102
BIR	52	68	88	102	52	71	88	98	47	65	81	92*	29	52	66	82	43	63	78	88*					44	62	82	90	45	68	82	96	36	64	80	94
SHR	48	69	87	99	34	58	77	85	45	69	88	98*	36	59	73	90	42	64	82	99*					33	54	72	80	49	71	89	102	44	66	84	96
PRE													22	32	42	64	29	51	69	81*					26	58	72	78	49	61	88	96	45	50	83	97
NYL													20	42	63	68	37	60	81	95					36	54	68	78*	38	62	83	98	47	64	83	96
LEP													20	45	68	69	38	54	70	80					10	32	42	52*	34	52	66	74	29	50	66	78
DYR													(no spec)		16	26	1	16	16	81					10	24	42	81*	13	33	59	101	17	43	70	111
SCH													18	45	66	85	43	68	86	99					38	53	69	76*	24	44	83	93				
MAT																	45	62	79	85					38	56	68	75*	48	72	89	96	42	64	88	86
HEI																																				
FLE																																				
ATE																																				

1956

SUBJECT	JAN 10				JAN 17				FEB 10				MAR 28				MAR 23				APR 10				APR 24				MAY 29				JUN 3				JUN 5				JUN 5				JUN 21				JUN 21			
	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120	15	30	60	120
WIL	38	67	79	85																					38	72	88	107																								
WIN	30	68	82	90																					50	79	108	116																								
HAT	35	64	18	90																					54	77	95	107																								
TAG	33	54	63	78																					48	69	82	100																								
BRI	47	70	86	96																					64	83	96	112																								
NEE					22	46	64	76	23	57	74	82*	51	80	96	108									44	75	102	118																								
ALT					40	52	70	86	54	74	96	104	49	69	90	104*	45	68	90	105	46	69	90	105*					50	73	91	106	34	51	67	80	27	47	80	92									36	61	82	95
BIR					40	56	70	78	43	64	84	91	54	80	98	108*									46	78	98	111																	61	83	99	109				
SHP					45	59	72	80	46	68	86	96*	62	78	99	112	58	84	108	118	51	78	99	115*													46	66	81	92									68	80	101	114
PRE					44	60	76	84	38	54	60	68	42	69	84	97*	44	81	101	114	46	68	88	101*					50	69	82	93	41	58	71	82	45	62	79	90									43	62	79	89
NYL					38	52	77	84	49	71	87	98	38	60	82	102*	48	69	86	97	46	67	86	101*					30	45	60	76	34	52	69	78	40	62	79	95												
LEP					30	38	54	68	32	55	73	80*	40	60	83	93	45	70	85	98	43	67	82	92*					32	46	64	76	36	53	68	76	21	35	48	64												
DYR					26	52	72	86	27	54	68	80*	27	54	85	105	40	(no spec)	73	92	36	62	84	100*					34	65	70	102	32	53	70	81	40	no spec	no spec	74									36	53	76	91
SCH					30	35	49	91													52	70	78	90																									47	64	72	82				
MAU					22	40	66	74	34	74	89	98*	47	79	99	108	48	75	94	103	43	69	88	99*					47	78	91	102	42	57	68	74	28	54	69	78									40	64	78	95
MCI					46	65	83	98	30	46	64	74	40	66	92	110*	50	72	92	107	42	68	92	113*					50	74	92	108	34	54	71	83	38	61	81	99												
PLE													40	64	90	108	40	73	94	116*					36	69	88	99	30	54	74	88	37	62	76	79												
ATE													36	56	76	92	54	65	79	94*					58	67	84	92	25	54	66	76	43	65	81	95												

* Consuming irradiated foods oo Phenolsulfonphthalein

Appendix 3

MEDICAL NUTRITION LABORATORY

AN EVALUATION IN HUMAN BEINGS OF THE ACCEPTABILITY, DIGESTIBILITY, AND TOXICITY OF PORK STERILIZED BY GAMMA RADIATION AND STORED AT ROOM TEMPERATURE

REPORT 204
17 MAY 1957

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AN ACTIVITY OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

U. S. ARMY MEDICAL NUTRITION LABORATORY
Fitzsimons Army Hospital
Denver 8, Colorado

Report No. 204 17 May 1957

Report of

AN EVALUATION IN HUMAN BEINGS OF THE ACCEPTABILITY, DIGESTIBILITY AND TOXICITY OF PORK STERILIZED BY GAMMA RADIATION AND STORED AT ROOM TEMPERATURE

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Work Phase No. 5

AN EVALUATION IN HUMAN BEINGS OF THE ACCEPTABILITY, DIGESTIBILITY AND TOXICITY OF PORK STERILIZED BY GAMMA RADIATION AND STORED AT ROOM TEMPERATURE

OBJECT:

To assess in human beings the acceptability, digestibility and toxicity of pork sterilized by gamma radiation and stored at room temperature.

SUMMARY:

1. Ground pork, packed in enameled cans, irradiated at 3 million rep by a gamma ray source, and stored at room temperature for approximately a year, was found to be bacteriologically sterile and contained no exotoxins for mice or rats.

2. Such irradiated pork when fed to human subjects at a level of 32% of the dietary calories for a short period of time (15 days) produced no discernable toxic effects.

3. Such irradiated pork had sufficient changes in color, texture, odor, and flavor to make it unacceptable to the test subjects.

4. No differences were observed in the apparent digestibility of protein, carbohydrate or fat of the irradiated or control diets, or of the ability of the two diets to maintain nitrogen equilibrium.

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INTRODUCTION

The Quartermaster General and The Surgeon General of the United States Army have undertaken an elaborate program to explore the potentialities of the use of ionizing radiation in food preservation. This Laboratory has already completed four studies in human beings of the acceptability, digestibility, available metabolizable energy, and toxicity of some 42 different foods sterilized by gamma radiation and then stored in the frozen state until use (7,8,10). Such food had no toxic effects. There were slight decreases in acceptability of some of the food items, and there were a few unimportant differences between irradiated and control items in digestibility and available metabolizable energy. The present report describes the results of the first test that has been conducted in human beings of the safety, acceptability, and digestibility of an irradiated item of food that has been stored for a considerable length of time at room temperature since sterilization.

METHODS

Test Subjects. Ten young men served as test subjects for this study. They were conscientious objectors who had volunteered for this program as a means of fulfilling their Selective Service obligation. They were between 18 and 22 years of age and had passed a careful medical examination. During the study the men lived on the Metabolic Ward.

Irradiated Pork. The only food tested in this study was pork loin which had been ground, packed in No. 2 cans, and subjected to gamma radiation at a dosage of 3 million rep. Part of this lot of pork had previously been used for a study of its nutritional adequacy in animals (9). The results of this test were satisfactory although the investigator (9) had noticed some discoloration of the meat as well as an off-odor. The cans of pork were divided into five separate groups on the basis of the dates of irradiation. The first group of cans had not been enameled and a considerable number of them were slightly swollen or rusted on the outside. These cans were not used for human feeding although they were subjected to bacteriologic and animal toxicity tests.

Bacteriologic and Animal Toxicity Tests. Thirty-six individual cans, a 20% sample of each of the five groups, were tested separately. All cans were opened and sampled under sterile conditions. In addition, three composite samples were tested. The first two composites were prepared by mixing under sterile conditions the contents of all of the cans of groups 2 and 3; the third was taken from a composite of the cans of groups 4 and 5. Samples from individual cans weighed approximately 25 grams; those from the composite samples approximately 100 grams.

Each sample was tested for sterility by the following procedures. After mixing, approximately 1 gram was placed in each of four tubes of

fluid thioglycolate medium. Two of the tubes were placed in a water bath at 70°C. for 30 minutes to destroy vegetative bacterial cells, but not spores. All tubes were then incubated at 37°C. and observed for eight days. On the 4th day of incubation all tubes were subcultured to fresh thioglycolate medium, and smears were prepared. On the 8th day of incubation samples of both original cultures and subcultures were again examined by gram stained smears and subcultured on 5% blood agar plates. A diphtheroid organism was cultured from two separate cans from group one, the unenameled cans. All other smears and cultures were negative.

Exotoxin assays were performed in the following manner. To 10 grams of each food sample was added 10 to 15 ml. of sterile distilled water, and the material shaken for 10 minutes. One-half ml. of the supernatant was then injected intraperitoneally into each of five CF-1 white mice weighing 20 to 25 grams. All mice were observed for an eight-day period, and were then again injected intraperitoneally with 0.2 ml. of the thioglycolate cultures and observed for another period of four days. None of the mice suffered any ill effects from the injections of extracts or cultures from the meat samples. In addition, samples of the first and third composites were fed as the only source of food for five days to two groups of five rats each which had previously been starved for a period of three days. No toxic effects were observed in any of the rats fed the irradiated pork. With the results described here, the irradiated pork from the four groups of enameled cans was considered safe for human feeding.

General Plan of the Study. The study consisted of two 15-day periods separated by a rest period of five days. During the first 15-day period, five of the subjects received the diet containing irradiated pork, while the other five received a similar diet containing non-irradiated pork. During the second 15-day period those subjects who had first received the irradiated food received control food, and vice versa. The diets were of constant composition and the subjects were required to consume them completely. During the central five days of each 15-day period, all feces and urine were collected for analysis in order to measure digestibility and nitrogen balance. Throughout both 15-day periods, a series of clinical examinations and clinical laboratory procedures were carried out on each subject as a check against any possible toxic effects from the food.

Preparation of Diets. Two constant metabolic diets were prepared which were identical except that one contained irradiated pork and the other non-irradiated pork. A single menu was prepared (see table 1). After the cans of irradiated pork were opened for bacteriologic examination and mixed, samples were analyzed chemically. The remainder of the irradiated pork was made up into weighed patties and stored frozen until use. On the basis of the chemical examination of this irradiated pork, an attempt was made to prepare from pork loin obtained at the Post commissary a ground pork product similar in composition to the irradiated pork. The results of the chemical analyses of the irradiated pork and of this control pork are given in table 2. All other foods used in

preparing the diets were obtained from the Post commissary. Wherever possible, foods from the same packing lots were used. The diet was prepared to provide approximately 2700 Calories of which 32% of the calories were to be supplied by the ground pork. Composites of the diet excluding pork were also analyzed chemically, with results also shown in table 2. In addition, the subjects received small amounts of nitrogen in tea or coffee; the amounts were the same each day for an individual and were added to the diet figures in calculating individual nitrogen intake. Except as noted, all analytical methods were those of the A.O.A.C.

Because the irradiated pork was somewhat discolored and had an abnormal odor, samples of both irradiated and control pork were tested chemically by the thiobarbituric acid reaction which may be considered a measure of rancidity. The method was essentially that of Biggs and Bryant (3). The meat samples were ground to a paste consistency and refluxed one hour with 2-thiobarbituric acid at a temperature of 65°C. under an atmosphere of nitrogen. The orange-red color produced was measured spectrophotometrically at 535 millimicrons. The color reaction measures the aldehydes formed by oxidation, primarily of certain lipids. Since the fat content of these samples varied somewhat the results were expressed in the amount of color produced per unit weight of lipid in the sample. The results are listed in table 3.

Clinical Examinations. Before the test and at the end of each 15-day period, each man received a careful physical examination, an electrocardiogram and a chest X-ray. The subjects were weighed each morning upon arising. Blood pressure, pulse, respiration and body temperature were measured several times daily. Each man kept a diary in which he recorded any symptoms which might have bearing on the test.

Clinical Laboratory Tests. Before, during and after eating of irradiated food, the following clinical laboratory tests were carried out:

Hematology: hemoglobin (4), hematocrit, total and differential white blood cell count.

Liver function: 45 minute bromsulfalein retention, both total and one-minute serumbilirubin (6), thymol turbidity, alkaline phosphatase (12), and prothrombin time.

Renal function: complete urine analysis and phenolsulfonphthalein excretion test.

Digestibility and Nitrogen Balance. During the central five days of each 15-day period, complete collections were made of urine and of feces on each subject. Urine was analyzed for nitrogen, and feces were analyzed for moisture, ash, fat and nitrogen. From these data and the results of analyses of food composites, the apparent digestibilities of protein, fat and carbohydrate were calculated, as was nitrogen balance.

Acceptability. Food acceptability data on the irradiated pork were obtained in two ways. Three times during each 15-day period, each subject noted his reaction to each individual food in the diet on the nine-point hedonic scale developed by the Quartermaster Food and Container Institute. In addition, each man was interviewed at the end of the study in order to obtain his impressions about any differences noted in color, texture, odor and flavor of the food items. All items on the menu were discussed.

RESULTS

Clinical Examinations. The various clinical examinations showed no changes that could be attributed to the ingestion of irradiated food. Some of the men lost small amounts of weight during the period of feeding; blood pressure, pulse rate, respiration and temperature remained within normal limits. Chest X-rays and electrocardiograms showed no changes from the control normal records.

Clinical Laboratory Tests. The series of clinical laboratory tests that were performed at various intervals before, during and after the feeding of irradiated food showed no significant changes in any of the subjects. Although there were occasional results that might be considered outside the range of normal, these variations did not appear to be of significance. In particular, there were no changes correlated with the feeding of irradiated food. The results are listed in the appendix.

Digestibility and Nitrogen Balance. The values of apparent digestibility of protein, fat and carbohydrate and of nitrogen balance calculated from the results of analysis of diets, feces and urine are given in table 4. Mean values of the digestibility and nitrogen balance figures did not differ significantly from control to irradiated diets.

Acceptability. The acceptability rating data showed a marked difference in acceptability between the irradiated and control pork. On the nine-point hedonic scale in which 1 is "like extremely" and 9 is "dislike extremely" the irradiated pork was given an average rating of 7.9, whereas the control pork received an average rating of 4.4. Although one subject found the irradiated pork more acceptable than the control, nine of the ten men much preferred the control to irradiated pork. The difference in acceptability rating of the two meats was statistically significant at the 1% level. Analysis of variance of the data revealed a statistically significant difference between ratings on the first and second 15-day periods. Control pork was rated less favorably during the second period than during the first. Irradiated pork was rated uniformly unfavorably throughout the study. The differences in color, texture, odor and flavor between the two meats which were observed by the subjects are listed in table 5. All the subjects noted the darker color of irradiated pork as compared to the control pork. Subjects noted a flavor difference and a majority noted a difference in odor.

Most of the subjects also noted a difference in texture; irradiated pork was described as softer in texture than the control pork; it "fell apart more readily."

DISCUSSION

Irradiated pork used in this study was off-color, and the texture, odor and flavor were considerably altered. The cause of these changes in the food is not known. Possibly the method of packing may have had some effect upon the food. Certainly it was noted that pork packed in unenameled cans had deteriorated more than that in enameled cans. The only cans which were not bacteriologically sterile had not been enameled. However, only food from enameled cans was used in the present test. Although the dosage of radiation used on the food in the present test, 3 million rep, has not always been sufficient to destroy all bacteria (1), it apparently did so in the present instance. Such doses of radiation, however, are known to be insufficient to inactivate enzymes in the food (5). Such enzymes may act to cause breakdown of protein, fat and carbohydrate during room temperature storage of the canned product. There is some evidence that this actually did take place from the high thiobarbituric acid reaction values obtained on samples of the irradiated pork. It should be noted, however, that the control pork in this study did not come from the same batch as the irradiated pork. This fact is a major defect in this whole study and tends to vitiate all comparisons of differences between the irradiated and control pork.

Although irradiated ground pork was certainly unacceptable, it had no toxic effects when fed to the test subjects as far as could be determined. In this regard the room temperature stored irradiated pork was a perfectly satisfactory product. These results, however, do not preclude the possible development of toxic effects from such a product when it is fed over a much more prolonged period of time. Although most of the subjects lost some weight while consuming the diets, the weight loss was no greater on the irradiated diet than on the control diet. The cause of the weight loss was presumably the fact that the total caloric intake was only 2700 Calories, whereas previous experience with such subjects indicates that the usual daily caloric requirement is about 3000 Calories.

The apparent digestibility of protein, carbohydrate and fat in the two diets, and the ability of the two diets to maintain nitrogen balance, were almost exactly the same. It is apparent, however, that there may very well be differences in the digestibility of the foodstuffs from irradiated or non-irradiated meat and in the ability of protein in irradiated and non-irradiated meat to maintain nitrogen balance. Since the irradiated meat provided only 32% of the calories of the diet, non-test foodstuffs could have masked any differences.

ACKNOWLEDGMENTS

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TABLE I

MENU

Breakfast	Lunch	Dinner
Sliced Peaches	Baked Pork Pattie*	Baked Pork Pattie*
Corn Flakes	Steamed Potatoes	Steamed Noodles
Scrambled Eggs	Green Beans	Peas
Bread	Bread	Bread
Butter	Butter	Butter
Grape Jelly	Grape Jelly	Grape Jelly
Milk	Applesauce	Pears
Sugar	Milk	Apple Juice
Coffee or Tea	Coffee or Tea	

*Irradiated

TABLE II

DIET COMPOSITION

	Nitro. gm.	Protein gm. 1/	Fat gm.	CHO gm. 2/	Ash gm.	Moisture gm.	M.E. Cal. 3/	Bomb Cal.	Gross Cal. 4/
Composite minus pork 5/	8.1	51	68	263	3.3	1300	1873	1927	2024
Irradiated Pork (330 gm.) 6/	9.8	61	67	3	3.0	196	876	971	993
Control Pork (330 gm.) 6/	9.2	58	62	0	3.0	208	802	904	911
Irradiated Diet	18.0	112	135	267	6.3	1495	2749	2898	3017
Control Diet	17.4	109	130	264	6.3	1507	2675	2831	2935

1/ Nitrogen x 6.25.
2/ By difference.
3/ Metabolizable Energy. Composites calculated with Atwater's general factors: protein 4, fat 9, and CHO 4 Cal./gm. Pork calculated with specific physiological energy factors for pork: protein 4.27, fat 9.02, and CHO 3.87 Cal./gm. from reference 9.
4/ Composites calculated with Atwater's general gross energy factors: protein 5.65, fat 9.40, and CHO 4.15 Cal./gm. Pork calculated with Atwater's specific gross energy factors for pork: protein 5.65, fat 9.50, and CHO 3.90 Cal./gm. from reference 10.
5/ Mean of 3 composites analyzed.
6/ Mean of 5 samples analyzed.

TABLE III

THIOBARBITURIC ACID REACTION OF IRRADIATED AND CONTROL PORK

CONTROL PORK			IRRADIATED PORK		
Sample	% Fat	O.D.*	Sample	% Fat	O.D.*
1	19.68	0.198	1	20.81	0.282
2	18.64	0.187	2	19.44	0.336
3	18.86	0.193	3	20.68	0.279
4	17.23	0.183	4	19.84	0.261
5	18.83	0.179	5	20.43	0.292
Mean	18.65	0.188	Mean	20.24	0.290

*Optical density per 0.5 gm. fat.

TABLE IV

DIGESTIBILITY AND NITROGEN BALANCE

	Subject	Period	Apparent Digestibility			Nitrogen Balance
			Protein	Fat	Carbohydrate	gm. per 5 days
CONTROL DIET	BAR	2	0.920	0.972	0.978	+ 6.88
	HUE	2	0.926	0.971	0.978	- 4.90
	SHM	2	0.914	0.964	0.974	- 3.06
	BAL	2	0.928	0.973	0.986	+14.05
	REI	2	0.908	0.984	0.971	+ 1.59
	HEI	1	0.933	0.974	0.960	- 2.76
	GRO	1	0.896	0.969	0.942	+ 8.68
	SBE	1	0.929	0.971	0.987	- 7.84
	SBH	1	0.937	0.968	0.965	+ 7.72
	SHR	1	0.962	0.987	0.988	+ 5.94
	Mean		0.925	0.973	0.973	+ 2.63
	Standard Deviation		0.018	0.007	0.014	7.08
IRRADIATED DIET	BAR	1	0.956	0.977	0.989	+ 4.70
	HUE	1	0.910	0.972	0.974	+22.64
	SHM	1	0.914	0.965	0.974	- 2.18
	BAL	1	0.914	0.967	0.984	-16.25
	REI	1	0.900	0.981	0.975	+ 2.57
	HEI	2	0.927	0.978	0.945	- 7.09
	GRO	2	0.892	0.966	0.951	+ 9.18
	SBE	2	0.931	0.965	0.985	+ 2.80
	SBH	2	0.929	0.973	0.970	+ 8.05
	SHR	2	0.940	0.981	0.979	+ 6.36
	Mean		0.921	0.973	0.973	+ 3.08
	Standard Deviation		0.019	0.007	0.014	10.35

TABLE V

OBSERVATIONS BY TEST SUBJECTS ON IRRADIATED PORK

SUBJECT	COLOR	TEXTURE	ODOR	FLAVOR
BAR	Brown (Control Gray)	Crumbly. Didn't hold together like control pork.	None	Undesirable
BAL	Dark	Soft	Irritating	Bitter
GRO	Reddish (Control light)	None	Different	Not a good taste
HEI	Reddish	Not solid-fell apart.	Undesirable-mixture between spoiled & burnt.	Little flavor
HUE*	Dark	None	None	Very good
REI	Dark	Broke apart easily.	Different	Slightly undesirable.
SHM	Somewhat red	None	Slightly different	Bitter
SHR	Dark red (Control light)	Loose	Distinctive undesirable	Undesirable first few days, but alright after becoming used to flavor.
SBE	Dark	None	Funny	Rotten
SBH	Dark	Less coarse than control	None	Burnt

*The only subject who preferred the irradiated pork to the control.

APPENDIX

CLINICAL LABORATORY TESTS

(Data obtained during the feeding of irradiated food are underlined.)

Hemoglobin: gm.%

Date	BAR	REI	BAL	HUE	SHM	SBE	SHR	HEI	SBH	GRO
25 Feb	14.8	14.0	13.8	14.0	13.8	14.6	16.1	12.3	13.5	13.8
18 Mar	13.2	12.6	12.6	11.3	11.6	14.7	13.0	13.2	11.5	12.6
27 Mar	14.2	14.2	14.0	13.0	13.8	15.9	14.1	12.9	13.8	13.0
6 Apr	13.7	13.2	13.0	12.8	13.0	14.2	13.0	12.3	12.8	13.5
16 Apr	17.6	13.0	16.2	14.4	14.4	17.4	14.4	16.0	15.0	13.5
15 May	15.4	12.3	14.6	14.1	13.4	16.3	13.0	12.4	12.6	13.5

Hematocrit: % cells

Date	BAR	REI	BAL	HUE	SHM	SBE	SHR	HEI	SBH	GRO
25 Feb	41	42	41	39	41	44	51	36	40	39
18 Mar	43	37	35	36	36	48	41	39	35	43
27 Mar	40	39	39	36	40	49	43	37	38	36
6 Apr	39	40	37	40	40	43	39	36	39	40
16 Apr	46	41	42	40	42	47	39	38	39	40
15 May	45	35	41	40	36	45	39	36	35	40

White Blood Cell Count: per cu. mm.

Date	BAR	REI	BAL	HUE	SHM	SBE	SHR	HEI	SBH	GRO
25 Feb	5250	7550	9850	8500	6950	7150	7400	4250	5350	10350
18 Mar	7500	9400	8300	5850	8700	6900	5200	8250	6650	10900
27 Mar	7900	9400	6500	5600	8900	6500	4850	7350	7750	7500
6 Apr	4900	10750	5350	4700	8300	5200	4700	4850	5900	7300
16 Apr	7250	7210	7300	7750	7700	8550	5750	5500	7000	5200
15 May	8450	7700	5900	6650	8150	5600	5600	5050	6100	5200

Total Serum Bilirubin: mg.%

Date	BAR	REI	BAL	HUE	SHM	SBE	SHR	HEI	SBH	GRO
27 Feb	0.6	1.1	0.6	1.0	1.3	0.7	0.6	0.9	0.8	0.7
18 Mar	0.7	0.6	0.3	0.5	0.6	0.9	0.6	0.4	0.6	0.4
27 Mar	0.9	1.0	0.6	0.7	0.9	0.4	0.6	0.8	0.8	1.1
6 Apr	0.6	1.1	0.6	0.8	0.8	0.8	0.5	0.6	0.5	0.6
16 Apr	0.8	0.8	0.6	0.7	1.2	0.7	0.5	0.8	0.6	0.7
15 May	0.3	0.7	0.6	0.3	0.8	0.5	0.3	0.6	0.3	0.3

APPENDIX (Cont.)

CLINICAL LABORATORY TESTS

One Minute Direct Serum Bilirubin: mg.%

Date	BAR	REI	BAL	HUE	SHM	SBE	SHR	HEI	SBH	GRO
27 Feb	.15	.27	.17	.30	.27	.15	.17	.45	.33	.27
18 Mar	.25	.13	.13	.10	.18	.18	.18	.06	.17	.17
27 Mar	.13	.17	.10	.13	.17	.20	.17	.25	.20	.15
6 Apr	.12	.18	.12	.18	.12	.16	.12	.12	.12	.12
16 Apr	.18	.23	.15	.18	.13	.23	.13	.18	.18	.15
15 May	.17	.24	.11	.11	.34	.13	.20	.11	.11	.11

Thymol Turbidity Test: MacLagan Units

Date	BAR	REI	BAL	HUE	SHM	SBE	SHR	HEI	SBH	GRO
27 Feb	3.0	2.0	2.0	1.0	4.0	2.0	1.0	1.0	2.0	4.0
18 Mar	2.0	1.0	3.0	1.5	1.0	1.5	1.0	1.0	1.0	4.0
27 Mar	3.5	3.0	2.0	3.0	4.0	1.2	1.0	1.5	1.0	5.0
6 Apr	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	6.0
16 Apr	1.0	1.0	1.0	1.0	2.0	1.5	1.0	1.0	1.0	5.0
15 May	5.0	2.0	2.0	2.0	3.0	3.0	1.0	1.0	1.0	5.0

Alkaline Phosphatase: Shinowara Units

Date	BAR	REI	BAL	HUE	SHM	SBE	SHR	HEI	SBH	GRO
27 Feb	4.2	10.1	6.2	2.1	5.9	1.9	3.1	3.2	2.6	1.7
18 Mar	1.6	5.2	3.1	1.0	3.9	2.8	4.0	2.6	4.4	3.8
27 Mar	3.2	7.2	5.3	1.9	3.3	2.3	4.6	2.8	3.4	2.8
6 Apr	4.0	6.4	3.9	0.8	2.6	1.7	2.2	2.1	3.4	3.8
16 Apr	3.8	7.8	4.4	1.6	4.3	1.2	4.7	2.2	4.4	2.9
15 May	4.6	6.5	6.3	1.9	4.6	2.9	4.1	3.1	3.6	3.3

Bromsulfalein Test: % Retention at 45 min.

Date	BAR	REI	BAL	HUE	SHM	SBE	SHR	HEI	SBH	GRO
27 Feb	3.3	4.8	6.3	5.6	3.5	2.9	2.9	3.5	4.3	3.2
20 Mar	2.9	3.1	3.0					2.7		
27 Mar	3.0	4.8	3.3	3.2	2.3	2.3	1.9	3.2	3.5	2.3
3 Apr	3.2	3.5	3.3					2.3		
10 Apr	1.9	3.5	2.3					2.4		
16 Apr	3.1	3.2	2.8	3.0	3.1	2.3	2.3	2.9	3.2	2.2
15 May	2.5	3.2	4.8	2.6	2.6	1.8	1.8	1.9	2.6	2.2

APPENDIX (Cont.)

CLINICAL LABORATORY TESTS

Prothrombin Time: % of Normal

Date	BAR	REI	BAL	HUE	SHM	Date	SBE	SHR	HEI	SBH	GRO
25 Feb	100	100	100	100	100	25 Mar	100	100	100	100	100
12 Mar	100	100	100	100	100	1 Apr	100	100	100	100	100
15 Mar	92	100	96	100	100	4 Apr	100	100	100	96	100
22 Mar	92	100	100	96	100	8 Apr	100	100	89	100	100
27 Mar	100	100	100	100	100	16 Apr	100		100	92	100
1 Apr	91	95	95	88	95	23 Apr	100	100	100	100	100
8 Apr	100	88	96	100	100	1 May	100	100	100	100	100

Phenolsulfonphthalein Excretion: % excreted in 15 and 120 minutes.

Date	BAR		REI		BAL		HUE		SHM	
	15'	120'	15'	120'	15'	120'	15'	120'	15'	120'
26 Feb	42	91	38	94	40	94	44	93	44	98
27 Mar	35	74	36	78	31	82	34	79	35	78
17 Apr	36	80	36	83	43	86	40	83	41	91
16 May	32	82	38	90	30	87	42	92	27	90

Date	SBE		SHR		HEI		SBH		GRO	
	15'	120'	15'	120'	15'	120'	15'	120'	15'	120'
26 Feb	29	95	44	75	34	92	38	88	9	94
27 Mar	26	71	38	77	32	91	32	80	39	90
17 Apr	38	86	36	78	40	92	35	84	38	83
16 May	35	88	34	78	35	90	46	98	35	93

Appendix 4

U S ARMY MEDICAL NUTRITION LABORATORY

SHORT-TERM HUMAN FEEDING STUDIES OF FOODS STERILIZED BY GAMMA RADIATION AND STORED AT ROOM TEMPERATURE

REPORT 224
1 JULY 1958

AN ACTIVITY OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

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Fitzsimons Army Hospital
Denver 8, Colorado

Report No. 224 1 July 1958

Report of

SHORT-TERM HUMAN FEEDING STUDIES OF FOODS STERILIZED BY GAMMA RADIATION AND STORED AT ROOM TEMPERATURE

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Project No. 6-60-11-020
Metabolism and Nutrition
USAMNL Subproject No. 12
Workphase Nos. 7 and 8

SHORT-TERM HUMAN FEEDING STUDIES OF FOODS STERILIZED BY GAMMA RADIATION AND STORED AT ROOM TEMPERATURE

OBJECT:

To determine the nutrient content and to test for the appearance of decomposition products in foods which have been treated with ionizing radiations and stored 3 months at room temperature; and to test the acceptability and possible acute toxicity of the foods in human subjects.

SUMMARY AND CONCLUSIONS:

Eighteen foods, including 5 meats and meat products, 6 vegetables, 6 fruits and fruit products, and one cereal, were frozen, irradiated at the following levels (rep), and subsequently stored 3 months at room temperature: potatoes, 10,000; flour, 75,000 - 80,000; oranges, 150,000; all others, 2,500,000 - 4,000,000. The control foods were similarly frozen, but were stored in the deep-freeze. Three alternate diets were prepared in which the irradiated (or the identical control) foods constituted 80% of the total calories; they were fed to 13 volunteer human subjects during 15 days of control diets and 15 days of irradiated food diets. The foods contained no soluble substances toxic to mice; no clinical abnormalities were noted in the human subjects. Irradiation decreased the thiamine and ascorbic acid content and increased the "browning reaction" derivatives, fat soluble carbonyl compounds, and thiobarbituric acid reactants. Except for string beans and orange juice, no significant differences in acceptability were noted between the irradiated and control foods.

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INTRODUCTION

As part of a large scale program initiated to evaluate the use of radiation in food preservation, human feeding studies of the nutritional aspects and possible toxic effects of irradiated foods have been conducted periodically on the Metabolic Research Ward of the U. S. Army Medical Nutrition Laboratory (1,2,3,4). To date, four human feeding studies of the acceptability, digestibility, available metabolizable energy, and toxicity of some 42 different foods sterilized by gamma radiation and stored frozen until use have been completed (1). In addition, one irradiated food (pork), stored at room temperature for approximately one year, was evaluated in a short-term feeding study (4). Thus far there have been no discernible toxic effects attributable to irradiated foods, whether stored frozen or at ambient temperature. Differences in acceptability of some of the food items have been noted in previous reports (3,4).

The present report describes the results of the sixth and seventh short-term human feeding studies of irradiated food items. Eighteen different foods were tested in these studies, all stored at room temperature for approximately three months after irradiation. This brings the number of food items that have been irradiated and stored at room temperature prior to testing to a total of nineteen. All of these foods were found to be bacteriologically sterile and nontoxic in animals prior to use.

METHODS

Test Subjects

Thirteen young men served as test subjects in the present studies; six of them participated in both tests. They were conscientious objectors who had volunteered for this program as a means of fulfilling their Selective Service obligation. All of the men were between 20 and 23 years of age and had passed a careful medical examination prior to admission. During the study, the men lived on the Metabolic Ward.

General Plan

Each study was approximately 30 days in length. During November 1957, each of ten subjects received an irradiated food diet for two 7-day periods alternating with two control diet periods. Half of the group was on the irradiated diet during any one period while the other subjects were receiving the control diet.

During March 1958, each of 9 subjects received an irradiated food diet for one 15-day period and a control diet during the other period. Again, the subjects were divided into two groups, each group received irradiated food for one of these periods while the other received the control diet.

Thus, each subject was given irradiated food for 15 days and served as his own control for the other 15 days.

Foods

Test foods, both irradiated and control, were received through the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois. Most of the food items were canned; half of each lot was subjected to varying doses of gamma radiation at either Idaho Falls or Dugway, Utah, and subsequently stored at room temperature approximately 3 months prior to testing.

During November 1957, 8 different food items were tested (Table 1). All test foods, both irradiated and control, came from the same lot, except control potatoes which were procured locally. Three rotating menus were used, which supplied approximately 80% of the calories from irradiated foods (Table 2).

During March 1958, 14 different food items were tested, four of which were also fed during the previous study (Table 1). All test foods, both irradiated and control, came from the same lot, except control potatoes and cabbage (for coleslaw) which were procured locally. Again, three rotating menus were used, with approximately 80% of the calories being derived from irradiated foods (Table 3). Non-test foods, which were used to supply the balance of calories in both studies, were procured locally.

Since these were not balance studies, every attempt was made to serve the food items in forms that would be most acceptable to the subjects.

Bacteriologic and Animal Toxicity Tests

All cans of processed food, both control and irradiated, were tested. The raw foods, white potatoes and oranges, were sampled at random. The irradiated coleslaw was sampled by random selection of several polyethylene bags. The control coleslaw was prepared from cabbage purchased locally and was not tested bacteriologically. The cans of flour, both control and irradiated were tested by random samplings.

Each sample was tested for sterility by the following procedures: After mixing, approximately 1 gram was placed in each of four tubes of fluid thioglycolate medium. Two of the tubes were placed in a water bath at 70°C. for 30 minutes to destroy vegetative bacterial cells, but not spores. All tubes were then incubated at 37°C. and observed for eight days. On the 4th day of incubation all tubes were subcultured to fresh thioglycolate medium, and smears were prepared. On the 8th day of incubation samples of both original cultures and subcultures were ap n examined by Gram stained smears and subcultured on 5% blood agar p es. All smears and cultures were negative.

Exotoxin assays were performed in the following manner: To 10 grams of each food sample was added 10 to 15 ml. of sterile distilled water, and the material shaken for 10 minutes. One-half ml. of the supernatant was then injected intraperitoneally into each of five CF-1 white mice

weighing 20 to 25 grams. All mice were observed for an eight-day period, and were then again injected intraperitoneally with 0.2 ml. of the thioglycolate cultures and observed for another period of four days. None of the mice suffered any ill effects from the injections of extracts or cultures from irradiated food samples.

Chemical Analyses

Proximate chemical analyses were performed on random samples of the individual test foods, both control and irradiated. Analytical methods were those of the A.O.A.C. (5) as utilized by this laboratory. Bomb calorimetric studies were done by a standard method as modified by Cleland and Harding (6). In addition, determinations of thiobarbituric acid reactants (7), carbonyl containing compounds (8), non-protein nitrogen (9,10), and the content of several vitamins (11,12), were performed on these samples.

Clinical Examinations

Each man received a physical examination, electrocardiogram and chest x-ray before and at intervals after each irradiated food study. The subjects were weighed each morning upon arising. Blood pressure, pulse, repsiration and body temperature were measured several times daily. Each man was encouraged to report any symptoms which might have bearing on the tests.

Clinical Laboratory Tests

Before, during and at intervals after feeding of irradiated food, the following clinical laboratory tests were carried out:

Hematology: hemoglobin (13), hematocrit, total and differential white blood cell count (14).

Liver function: 45 minute bromsulfalein retention (15), both total and one-minute serum bilirubin (16), thymol turbidity (14), alkaline phosphatase (17), and prothrombin time (18).

Renal function: complete urine analysis and phenolsulfonphthalein excretion tests (14).

Urinary Excretion Tests

In an effort to further assess possible toxic effects of irradiated foods on humans, several urinary excretion studies were performed. Since many foreign substances are frequently detoxified by the liver and excreted in combination with glucuronic acid, urine glucuronides were measured (19). In addition, determinations of the urinary excretion of total ketones (20), nitroprusside-reacting substances (21), and indophenol reducing substances (22,23) were performed. Total urine organic acidity

was measured by a modification of the method of Van Slyke (24).

Acceptability

Acceptability data on irradiated foods were obtained in two ways. Several times during each feeding period, the subjects noted their reaction to each individual food in the diet on the five-point hedonic scale developed by the Quartermaster Food and Container Institute (Table 4). In addition, each man was interviewed at the end of the study in order to obtain his impressions about any differences noted in color, texture, odor and flavor of the food items, during the feeding periods.

RESULTS

Clinical Examinations

Physical examinations revealed no changes that could be attributed to the ingestion of irradiated food. Chest x-rays and electrocardiograms remained essentially unchanged from normal controls obtained prior to testing. Fluctuations in weight, blood pressure, pulse, respiration, and body temperature remained within normal limits except during those periods when the subjects had seasonal respiratory tract infections, influenza and other unrelated disorders.

Clinical Laboratory Tests

The series of tests that were performed at various intervals before, during, and after the feeding of irradiated food showed no significant changes in any of the subjects (Appendix). Although there were occasional results that might be considered outside the normal range, these variations did not appear to be of clinical significance and could not be related to the ingestion of irradiated food.

Urine Excretion Tests

Determinations of urinary excretion products revealed no significant differences between the average values for the control and irradiated food periods in the case of total glucuronides, total ketones, total organic acidity, and nitroprusside-reacting substances (Figures 1 and 2). The excretion of indophenol-reducing substances was significantly increased ($p < .005$) during the irradiated food periods of the November study, but, on the other hand, was significantly decreased ($p < .001$) during the feeding of irradiated food in the March study.

Chemical Analyses

Proximate analysis of irradiated and control food samples revealed some minor differences in nutrient composition, but no consistent alterations were apparent (Tables 5 and 6). The gross caloric content of the foods appeared essentially unchanged as a result of irradiation.

The content of several vitamins, particularly thiamin and ascorbic acid, appeared to be somewhat reduced in many irradiated foods (Table 7). Thiobarbituric acid reaction values, presumably an index of aldehyde formation from certain lipids, were frequently elevated in irradiated foods. Compounds containing carbonyl groups were markedly increased in irradiated foods containing a relatively high proportion of fat. No increase in the non-protein nitrogen content of irradiated foods was observed (Table 7).

Acceptability

Statistical analysis of acceptability ratings for irradiated and control foods revealed significant differences in the average values of string beans and orange juice (Table 8). In both of these instances the control food was preferred. In general, most vegetables and fish items received the higher ratings, whether control or irradiated, indicating a dislike for these foods on the part of this group of subjects.

Individual interviews with the subjects revealed that they had no difficulty in distinguishing the feeding periods of control and irradiated food. Observations of the subjects concerning differences between irradiated and control food items are summarized in Tables 9 and 10. It is apparent that the majority of subjects noted differences in color, flavor, texture, and odor of all foods except items made with potatoes and flour. These differences were more consistently obvious in the case of green beans, corn and carrots where alterations in odor were noted.

DISCUSSION

Irradiated food produced no evident clinical abnormalities when fed to the test subjects in this study. Similar results have been reported in the previous short-term human feeding studies (1,4). Failure to produce toxicity was further evidenced by the lack of any consistent changes in the excretion of certain urinary constituents which may reflect alterations in ingested foodstuffs.

It is of interest that irradiation produced few changes in nutrient and caloric composition of the foods used in this study. In previous balance studies, the apparent digestibility of protein, carbohydrate and fat in irradiated and control diets were similar (2,4). In addition, the ability of the two diets to maintain nitrogen balance was shown to be essentially unchanged. The decreased thiamin and ascorbic acid content of certain irradiated foods used here is in accord with observations of other investigators. Proctor and Goldblith have reported that in solutions of various vitamins, ascorbic acid and thiamin are the most radiosensitive (25). Ziporin and coworkers (26) and Alexander, et al. (27) have shown that of the vitamins in several foods, thiamin is the most easily destroyed as a result of irradiation. The degree of radiosensitivity of vitamins apparently varies greatly among different food items.

Although there is evidence that irradiation of carbohydrates, proteins, and fats produces certain degradation products, no untoward effects were detected as a result of the ingestion of these products. It has been shown that the irradiation of carbohydrate produces some polymerization of breakdown products, leading to the formation of products typical of browning reactions (28). The urinary excretion of nitroprusside reacting substances, indophenol reducing substances, and ketones, which seem to reflect ingestion of these products of browning reactions (23), were not significantly increased in the test subjects during the irradiated food periods.

Fat soluble carbonyl compounds and thiobarbituric acid reactants are generally increased in foods subjected to irradiation (28). Results of analyses of the foods used in this study are in harmony with these observations. Alterations in proteins are known to occur as a result of irradiation, but significant protein breakdown, as indicated by non-protein nitrogen values, was not apparent in the foods tested. Thus an increase in products of proteolysis could not be detected in these room temperature stored foods following irradiation, although the doses of radiation used are known to be insufficient to inactivate enzymes (29).

In general, most of the irradiated foods tested were acceptable to the subjects. Alterations in several vegetables resulting from irradiation were profound, leading to a preference for the control food. On the other hand, foods such as potatoes and flour, subjected to lower radiation doses, were not detectably different following irradiation. Limitations affecting the interpretation and application of these acceptability data have been discussed in a previous report (3).

These results do not preclude the possible development of toxic effects from irradiated foods when fed to test subjects over a more prolonged period of time. In this regard, a long-term human feeding study of irradiated food is planned.

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Table 1

IRRADIATED FOOD VI - ROOM TEMPERATURE STORAGE
November 1957

FOOD ITEM	RADIATION DOSE rep
Codfish	4,000,000
Bacon	4,000,000
Fruit Compote	4,000,000
Chicken	3,000,000
Peaches	3,000,000
Green Beans	3,000,000
Flour	80,000
Potatoes	10,000

IRRADIATED FOOD VII - ROOM TEMPERATURE STORAGE
March 1958

Shrimp	4,000,000
Bacon	4,000,000
Tuna	4,000,000
Chicken Stew	4,000,000
Sweet Potatoes	3,000,000
Carrots	3,000,000
Corn	3,000,000
Pineapple Jam	3,000,000
Coleslaw	3,000,000
Peaches	3,000,000
Orange Juice	2,500,000
Oranges	150,000
Flour	75,000
Potatoes	10,000

Table 2

IRRADIATED FOOD VI - ROOM TEMPERATURE STORAGE
November 1957

MENU #1	MENU #2	MENU #3
BREAKFAST	BREAKFAST	BREAKFAST
*Chilled Peaches	*Chilled Fruit Compote	*Chilled Fruit Compote
*Bacon	*Bacon	*Bacon
*Bread	*Hot Biscuits	*Bread
*Jam	Honey	Jelly
LUNCH	LUNCH	LUNCH
*Creamed Chicken	*Baked Codfish Creole	*Baked Codfish Creole
*Mashed Potatoes	*Paprika Julienne Potatoes	*Baked Potatoes
*Seasoned Green Beans w/Bacon Drippings	*Buttered Green Beans	*Buttered Green Beans
*Hot Rolls	*Bread	*Hot Biscuits
*Jelly	*Jelly	Honey
*Fruit Compote	*Peaches	*Peach Pie
	*Filled Cookies	
DINNER	DINNER	DINNER
*Baked Codfish Creole	*Creamed Chicken	*Roast Chicken
*Oven Browned Potatoes	*Mashed Potatoes	*Scalloped Potatoes
*Buttered Green Beans	*Seasoned Green Beans w/Bacon Drippings	*Seasoned Green Beans w/Bacon Drippings
*Hot Biscuits	*Hot Rolls	*Hot Rolls
Honey	*Jam	*Jam
*Peach Pie	*Upside Down Cake(Peach) w/Whipped Cream	*Peaches
		*Spiced Fruit Cookies

* Irradiated

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Table 3

IRRADIATED FOOD VII - ROOM TEMPERATURE STORAGE
March 1958

MENU #1	MENU #2	MENU #3
BREAKFAST	BREAKFAST	BREAKFAST
*Orange Juice	*Orange Juice	*Orange Juice
*Crisp Bacon	*Crisp Bacon	*Crisp Bacon
*Bread	*Bread	*Bread
Butter	Butter	Butter
*Pineapple Jam	*Pineapple Jam	*Pineapple Jam
Coffee or Tea	Coffee or Tea	Coffee or Tea
Skim or Buttermilk	Skim or Buttermilk	Skim or Buttermilk
Sugar as desired	Sugar as desired	Sugar as desired
LUNCH	LUNCH	LUNCH
*Chicken Stew	*Tuna Salad	*Fried Shrimp
*Sweet Potato Puff	*French Fried Potatoes	*Sweet Potato Puff
*Corn	*Carrots	*Carrots
Relishes	*Coleslaw	Relishes
*Hot Rolls	*Hot Rolls	*Hot Rolls
Butter	Butter	Butter
Skim Milk	Skim Milk	Skim Milk
*Orange	*Peach Pie	*Upside Down Cake w/Whipped Cream
*Cookies		
DINNER	DINNER	DINNER
*Fried Shrimp	*Chicken Stew	*Tuna Salad
*French Fried Potatoes	*Sweet Potato Puff	*French Fried Potatoes
Relishes	Relishes	Relishes
*Hot Biscuits	*Corn	*Corn
Butter	*Hot Biscuits	*Hot Biscuits
Skim Milk	Butter	Butter
*Upside Down Cake w/Whipped Cream	Skim Milk	Skim Milk
	*Orange	*Orange
	*Cookies	*Cookies

* Irradiated

Table 4

FOOD CHECK LIST

DATE _____

DIET NO. _____ NAME _____

Food Items	1	2	3	4	5
1	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much
2	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much
3	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much
4	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much
5	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much
6	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much
7	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much
8	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much
9	Like very much	Like	Neither like nor dislike	Dislike	Dislike very much

Table 5

PROXIMATE ANALYSIS AND CALORIMETRY
IRRADIATED FOOD VI
November 1957

FOOD SAMPLE	% COMPOSITION (WET)												CALORIES	
	MOISTURE		ASH		NITROGEN		PROTEIN		FAT		CARBOHYDRATE		Gm.	
	C†	I*	C	I	C	I	C	I	C	I	C	I	C	I
Flour	11.3	11.3	0.43	0.45	1.91	2.03	11.9	12.7	2.5	2.3	73.8	73.2	3.89	3.89
Potatoes ‡	75.4	73.7	0.70	0.84	0.33	0.53	2.0	3.8	0.67	0.72	21.2	21.4	1.13	1.10
Bacon	24.3	23.6	1.93	1.86	1.38	1.43	8.6	8.9	63.2	62.3	2.0	3.4	6.67	6.78
Peaches	79.2	78.7	0.57	0.30	0.15	0.83	0.92	0.52	0.36	0.36	19.0	20.1	0.76	0.83
Fruit Compote	29.2	28.6	1.95	1.77	1.83	0.55	11.4	3.5	0.72	1.17	56.7	65.0	2.66	2.77
String Beans	90.5	89.3	0.68	0.74	0.28	0.37	1.74	2.31	0.14	0.30	6.9	7.4	0.36	0.46
Chicken	68.2	70.4	0.74	0.71	2.94	3.37	18.4	21.1	11.1	7.2	0.69	0.66	2.40	2.04
Codfish	77.7	79.4	1.04	1.06	3.06	3.08	19.1	19.2	0.18	0.45	2.0	0.1	1.15	1.07

* - I = Irradiated Food Sample
† - C = Control Food Sample
‡ - Control Food Procured Locally

Table 6

PROXIMATE ANALYSIS AND CALORIMETRY
IRRADIATED FOOD VII
March 1958

FOOD SAMPLE	% COMPOSITION (WET)										CALORIES	
	MOISTURE		ASH		NITROGEN		PROTEIN		FAT		CARBOHYDRATE		Gm.	
	C†	I*	C	I	C	I	C	I	C	I	C	I	C	I
Chicken Stew	74.4	72.7	1.15	0.70	1.64	1.58	10.2	9.9	6.0	11.4	8.2	5.3	1.41	1.86
Shrimp	70.5	77.6	1.76	1.20	4.4	3.2	27.4	19.9	1.08	0.76	0.72	0.56	1.52	1.08
Tuna	72.7	73.8	1.36	0.25	5.7	3.8	35.4	24.0	0.94	0.72	0.64	1.25	1.97	1.46
Sweet Potatoes	73.3	78.9	0.36	0.52	0.35	0.30	2.2	1.9	0.24	0.31	23.9	18.4	1.05	0.84
Oranges	88.6	89.1	0.35	0.32	0.42	0.19	2.6	1.2	0.24	0.18	8.2	9.2	0.44	0.40
Orange Juice (conc)	54.3	56.2	1.27	0.26	0.48	0.47	3.0	3.0	1.02	0.98	40.4	39.6	1.67	1.64
Coleslaw ‡	93.1	86.4	0.55	1.02	0.23	0.36	1.45	2.24	0.74	1.32	4.1	9.1	0.32	0.44
Carrots	91.3	91.4	0.34	0.52	0.25	0.30	1.54	1.88	0.60	0.16	6.3	6.1	0.35	0.33
Corn	75.0	84.0	0.18	0.41	0.56	0.44	3.5	2.8	0.94	0.72	20.4	12.1	1.16	0.64
Pineapple Jam	25.8	20.0	0.12	0.22	0.08	0.11	0.48	0.69	0.36	0.46	73.2	78.7	2.72	2.81

* - I = Irradiated Food Sample
† - C = Control Food Sample
‡ - Control Food Procured Locally

Table 7

THIOBARBITURIC ACID REACTION, CARBONYL COMPOUNDS, NON-PROTEIN NITROGEN AND VITAMIN CONTENT (raw)

IRRADIATED FOOD VI
November 1957

FOOD SAMPLE	TBA Values		NPN mg/100gm		Carbonyls moles/gm x 10^6		Thiamin µg/gm		Riboflavin µg/gm		Ascorbic Acid µg/gm	
	C†	I*	C	I	C	I	C	I	C	I	C	I
Flour ‡	0.03	0.05	3.1	3.0	2.6	4.1	4.67	4.57	2.5	4.1	16	21
Potatoes ‡	0.06	0.07					0.90	0.98	1.0	1.3	248	125
Bacon	0.06	0.18	2.4	2.5	33.1	51.2	3.71	0.22	1.1	0.8		
Peaches	0.06	0.12					0.12	0.04	0.4	0.5	105	13
Fruit Compote	0.08	0.08					0.18	0.13	3.7	1.2	309	
String Beans	0.05	0.09	0.6	0.6	2.1	1.5	0.43	0.11	2.1	1.5	277	61
Chicken	0.45	0.65					0.76	0.13	1.9	2.9	32	11
Codfish	0.03	0.05					0.51	0.05	0.8	1.4	22	20

IRRADIATED FOOD VII
March 1958

Chicken Stew	0.12	0.08	4.6	3.7	3.4	6.6	0.18	0.02	0.4	0.2	30	34
Shrimp	0.02	0.04	2.5	2.9			0.00	0.01	0.1	0.1	21	76
Tuna	0.48	0.08	3.4	2.8	2.5	3.8	0.07	0.00	0.2	0.1	42	89
Sweet Potatoes	0.05	0.09	1.1	1.4			0.22	0.00	0.2	0.1	86	147
Oranges	0.01	0.01	1.0	1.1			0.22	0.23	0.1	0.2	679	615
Orange Juice (conc.)	0.08	0.14	4.0	7.9			1.12	0.08	0.4	0.2	1109	850
Coleslaw ‡	0.03	0.03	0.6	1.0			0.15	0.21	0.2	0.3	497	359
Carrots	0.02	0.04	1.6	1.8			0.19	0.00	0.1	0.1	95	119
Corn	0.03	0.04	4.6	5.7			0.28	0.02	0.2	0.1	307	54
Pineapple Jam	0.05	0.13	0.9	0.8			0.27	0.02	0.8	0.2	207	525

* - I = Irradiated Food Sample
† - C = Control Food Sample
‡ - Control Food Procured Locally

Table 8
ACCEPTABILITY RATINGS OF IRRADIATED AND CONTROL FOOD
(Based on 5-Point Hedonic Scale)

IRRADIATED FOODS VI
November 1957

FOOD	AVERAGE RATINGS		SIGNIFICANCE OF DIFFERENCE
	Irrad.	Control	P Value
Flour	1.80	1.80	N.S.
Potatoes	2.26	2.33	N.S.
Bacon	2.12	1.65	N.S.
Peaches	1.72	1.52	N.S.
Fruit Compote	2.24	2.11	N.S.
String Beans	4.66	3.62	<.005
Chicken	2.88	2.24	N.S.
Codfish	3.42	3.32	N.S.

IRRADIATED FOODS VII
March 1958

Flour	1.52	1.60	N.S.
Potatoes	1.44	1.61	N.S.
Bacon	1.67	1.83	N.S.
Peaches	1.83	1.72	N.S.
Oranges	1.78	1.56	N.S.
Orange Juice	2.50	1.50	<.025
Coleslaw	3.39	2.78	N.S.
Carrots	3.50	3.00	N.S.
Corn	4.38	3.60	N.S.
Pineapple Jam	1.44	1.89	N.S.
Sweet Potatoes	2.22	2.11	N.S.
Chicken Stew	3.33	2.33	N.S.
Shrimp	2.72	2.44	N.S.
Tuna	2.61	2.56	N.S.

Table 9

IRRADIATED FOOD VI - ROOM TEMPERATURE STORAGE

November 1957 - 10 Subjects

DIFFERENCES OBSERVED BETWEEN IRRADIATED AND CONTROL FOODS

Irradiated Food Item	Prepared Food On Menu	Number of Subjects Observing Differences				
		No Difference	Flavor	Texture	Color	Odor
Flour	Bread	10				
Flour	Hot Rolls	10				
Flour	Hot Biscuits	10				
Potatoes	Mashed Potatoes	10				
Potatoes	Oven Browned Potatoes	10				
Potatoes	Paprika Julienne Potatoes	10				
Potatoes	Baked Potatoes	10				
Potatoes	Scalloped Potatoes	10				
Bacon	Bacon	1	7	3	7	
Peaches	Peaches		3	9	9	
Peaches & Flour	Peach Pie		2	8	9	
Peaches & Flour	Peach Upside Down Cake	4		4	6	
Fruit Compote	Fruit Compote		3	9	8	
Fruit Compote	Jam	7	1		2	
Fruit Compote and Flour	Filled Cookies	9			1	
Fruit Compote and Flour	Spiced Fruit Cookies	10				
Green Beans	Buttered Green Beans		10	9	10	2
Green Beans and Bacon	Buttered Green Beans w/Bacon Seasoning		10	9	10	2
Chicken	Creamed Chicken	4	5	4	2	
Chicken	Roast Chicken		7	6	5	
Codfish	Creole Codfish	2	6	6	8	

Table 10

IRRADIATED FOOD VII - ROOM TEMPERATURE STORAGE

March 1958 - 9 Subjects

DIFFERENCES OBSERVED BETWEEN IRRADIATED AND CONTROL FOODS

Irradiated Food Item	Prepared Food On Menu	No. of Subjects Observing Differences					No. Prefer Irrad.	Remarks
		No Diff.	Flavor	Texture	Color	Odor		
Flour	Bread	9						
Flour	Hot Rolls	9						
Flour	Hot Biscuits	9						
Flour	Spice Cookies	9						
Potatoes	French Fries	8	1					
Potatoes	Home Fries	8	1					
Bacon	Bacon	3	3		4			Darker, Stronger
Peaches & Flour	Peach Upside Down Cake	7		2	1			
Peaches & Flour	Peach Pie		1	4	9			Darker, Softer
Oranges	Sliced Orange	1	7		1			Tangy, Bitter
Orange&Flour	Orange Cookies	9						
Orange Juice	Orange Juice		9	5	9			Tangy,Darker,Settles Easily
Coleslaw	Spanish Coleslaw	4	3	1	4		1	Darker, Bitter
Carrots	Carrots	1	7	6	8	5	1	Darker, Softer
Corn	Corn		8	7	9	7		Darker, Softer, Tasteless
Pineapple Jam	Pineapple Jam		2	1	8			
Pineapple & Flour	Jam Bars	7	1	1	1			
Sweet Potatoes	Sweet Potatoes	2	6	1	4		6	Paler, Sweeter
Chicken Stew	Chicken Stew	7	2				2	
Shrimp	Fried Shrimp	5	1	1	2	2	1	Darker
Tuna	Creamed Tuna or Tuna Salad	7	2				5	

APPENDIX

CLINICAL LABORATORY TESTS

(Data obtained during the feeding of irradiated food are underlined)

Hemoglobin: gm.%

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
14 Nov	16.4	16.7	15.2	16.7	17.4	15.1	14.9	15.8	18.2	16.0			
21 Nov	16.0	16.4	16.0	16.4	18.0	15.5	14.5	16.4	16.4	15.5			
27 Nov	15.5	17.0	16.0	16.4	17.4	16.0			17.0	15.5			
6 Dec	17.0	17.0	16.4	16.4	18.0	16.4	14.2	15.5	17.0	15.1			
13 Dec	15.1	16.4	14.6	14.2	15.8	14.6	16.0	13.9	15.5	13.9			
7 Jan		18.0	16.0		18.0	17.0	16.0	18.0	17.4	17.4	14.8		
26 Feb		17.0	14.2					15.8				14.0	13.6
4 Mar					17.2	15.1	15.5		17.2	17.2	17.2		
19 Mar	16.7			16.0	15.5	13.7	12.4	14.8	17.0	15.1	14.3	14.3	14.9
2 Apr					15.8	13.9	13.1	15.1	17.0	15.5	14.9	15.1	15.0

Hematocrit: % cells

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
14 Nov	47	48	47	46	51	48	44	46	51	49			
21 Nov	45	48	47	48	52	48	43	46	47	48			
27 Nov	45	51		48	52	49			51	48			
6 Dec	48	50	48	49	53	48	44	48	51	46			
13 Dec	44	54	48	51	52	50	46	49	49	49			
7 Jan		52	47		52	51	47	50	49	50	51		
26 Feb		49	43									42	41
4 Mar					53	47	46		51	50	52		
19 Mar	53			50	53	48	43	46	54	50	47	47	49
2 Apr					52	47	44	46	52	51	50	48	51

APPENDIX

CLINICAL LABORATORY TESTS (Continued)

White Blood Cell Count: Thousands per cu. mm.

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
14 Nov	3.8	8.2	7.2	10.7	6.5	5.6	9.0	5.2	9.5	10.6			
21 Nov	7.0	7.5	4.9	9.5	6.7	4.6	4.9	5.8	9.5	7.0			
27 Nov	4.9	7.2	6.0	10.2	6.3	7.4	4.9	9.0	6.1	7.7			
6 Dec	6.0	7.7	6.8	9.9	8.1	5.6	7.7	6.0	9.2	7.1			
13 Dec	5.5	5.9	7.6	8.8	7.5	5.0	9.6	7.4	7.9	7.7			
7 Jan		4.9	9.0		10.3	5.3	8.2	6.5	8.7	9.2	7.5		
26 Feb		6.4	6.9					6.2				6.2	8.2
4 Mar					7.2	5.4	8.1		9.8	9.6	9.7		
19 Mar	5.1			10.5	7.5	6.4	8.2	6.5	9.5	7.8	9.7	6.5	8.7
2 Apr					7.6	4.9	7.0	6.5	7.9	9.2	9.3	9.4	5.9

Total Serum Bilirubin: mg.%

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
14 Nov	1.0	0.2	0.7	0.3	0.4	0.5	0.5	0.3	0.4	0.1			
21 Nov	1.6	1.0	0.6	0.6	1.0	0.3	0.8	0.7	0.4	0.5			
27 Nov	1.4	0.7	0.9	0.6	1.1	0.5	0.7	0.7	1.2	0.4			
6 Dec	1.0	1.0	0.4	1.1	1.4	0.4	0.4	0.8	0.8	0.5			
13 Dec	1.0	0.7	1.1	1.4	1.4	0.4	0.5	0.7	1.0	0.7			
7 Jan		0.7	0.8		0.5	0.4	0.4	0.7	0.8	0.5	0.4		
26 Feb		0.5	0.7									0.5	1.5
4 Mar					1.1	0.5	0.5	0.7	0.6	0.8	0.4		
19 Mar	1.7			0.8	1.0	0.2	0.2	0.2	0.7	0.8	0.4	0.5	1.6
2 Apr					1.0	0.2	0.2	0.2	0.5	0.9	0.7	0.6	2.2

APPENDIX

CLINICAL LABORATORY TESTS (Continued)

Direct (1 min) Serum Bilirubin: mg.%

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
14 Nov	0.3	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.3	0.1			
21 Nov	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.1			
27 Nov	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.2			
6 Dec	0.3	0.2	0.2	0.5	0.3	0.1	0.2	0.3	0.2	0.3			
13 Dec	0.1	0.3	0.3	0.4	0.3	0.1	0.2	0.2	0.2	0.2			
7 Jan		0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.2		
26 Feb		0.1	0.1									0.1	0.1
4 Mar					0.1	0.1	0.1	0.2	0.1	0.2	0.1		
19 Mar	0.1			0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2 Apr					0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Thymol Turbidity: MacLagen Units

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
14 Nov	1.4	5.5	7.0	5.2	3.0	2.3	7.0	5.0	6.2	1.5			
21 Nov	1.0	0.1	1.0	1.2	1.5	1.5	1.3	1.0	0.8	1.5			
27 Nov	0.1	1.6	2.0	1.0	1.0	1.0	2.0	1.0	1.0	2.0			
13 Dec	0.5	6.0	7.0	4.0	4.0	1.0	4.5	4.0	5.0	7.0			
7 Jan		4.0	5.0		3.0	2.0	5.0	2.0	4.2	6.0	5.0		
26 Feb		5.0	5.0									2.0	3.0
4 Mar					2.0	1.0	4.0	4.0	4.0	4.0	3.0		
19 Mar	1.0			3.0	2.0	1.0	4.0	4.0	4.0	5.0	2.0	3.0	4.0
2 Apr					2.0	1.0	5.0	4.0	4.0	5.0	1.0	3.0	4.0

APPENDIX

CLINICAL LABORATORY TESTS (Continued)

Alkaline Phosphatase: Shinowara Units

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
14 Nov	3.7	4.8	4.7	4.4	4.8	5.2	5.6	4.5	4.8	2.7			
21 Nov	4.4	5.6	3.8	4.3	2.9	5.0	4.5	4.6	4.9	2.8			
27 Nov	5.2	4.7	3.7	5.8	3.0	4.2	4.5	4.0	3.9	3.6			
6 Dec	3.4	4.6	4.6	5.1	3.6	4.3	4.3	3.8	4.6	3.2			
13 Dec	5.4	5.0	5.0	5.2	4.8	5.8	5.3	5.7	5.5	4.3			
7 Jan		3.9	3.8		2.6	4.3	3.4	4.1	4.0	3.2	5.6		
26 Feb		5.3	3.8									6.1	2.0
4 Mar					3.4	4.5	4.1	5.7	3.6	3.5	4.7		
19 Mar	3.3			4.0	3.7	4.9	4.2	4.1	4.5	3.4	5.4	6.9	2.6
2 Apr					2.6	5.0	4.2	3.5	4.0	3.0	5.8	7.6	2.6

Prothrombin Time: Seconds (Undiluted Plasma)

Date	ES	DS	DG	HS	AN	DH	VJ	RK	DD
26 Feb								13	13
4 Mar	14	14	17	13	14	14	14		
19 Mar	13	13	13	14	13	13	13	12	12
2 Apr	14	13	15	14	14	14	15	12	14

APPENDIX

CLINICAL LABORATORY TESTS (Continued)

BSP Test: % Retention at 45 min.

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
5 Nov	3.7	2.3	1.8	4.0	1.8	2.8	1.6	2.6	3.7	3.5			
13 Dec	4.0	3.2	1.6	2.5	2.8	1.6	2.0	3.2	5.7	3.2			
7 Jan		2.3	2.6		2.6	2.3	1.5	3.0	4.0	0.8	3.2		
26 Feb		4.5	2.6									3.6	5.7
4 Mar					2.3	2.6	2.6	3.2	4.0	6.7	4.0		
19 Mar	4.2			3.0									
2 Apr					1.6	2.3	2.3	5.7	6.0	5.7	3.0	2.3	2.6

PSP Test: % Excreted in 15 min.

Date	LF	RB	LS	JB	ES	DS	DG	HS	AN	DH	VJ	RK	DD
7 Nov	36	30	35	11	21	23	31	29	38	39			
14 Dec	25	28	27	19	46	26	28	30	31	28			
6 Jan		33	36								25		
3 Mar	30	30	36	31	26	33	34	46	31	30	26	30	10
3 Apr					27	32	28	34	33	23	28	28	

% Excreted in 120 min.

7 Nov	74	61	84	68	74	70	65	67	81	82			
14 Dec	70	69	68	58	87	61	72	72	69	69			
6 Jan		70	75								60		
3 Mar	73	82	102	65	72	67	74	88	66	75	58	70	75
3 Apr					75	63	70	69	77	61	58	70	

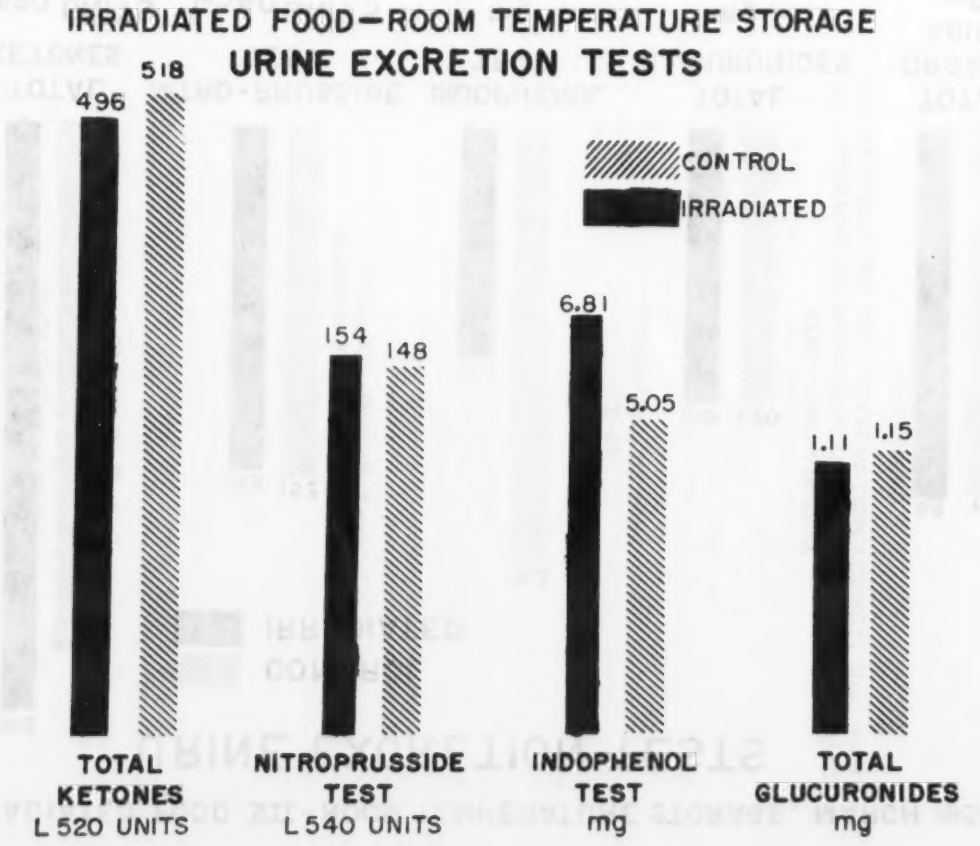
IRRADIATED FOOD—ROOM TEMPERATURE STORAGE
URINE EXCRETION TESTS
CONTROL
IRRADIATED
496
518
154
148
6.81
5.05
1.11
1.15
TOTAL KETONES L 520 UNITS
NITROPRUSSIDE TEST L 540 UNITS
INDOPHENOL TEST mg
TOTAL GLUCURONIDES mg

FIG. 1

IRRADIATED FOOD VII - ROOM TEMPERATURE STORAGE, MARCH 1958

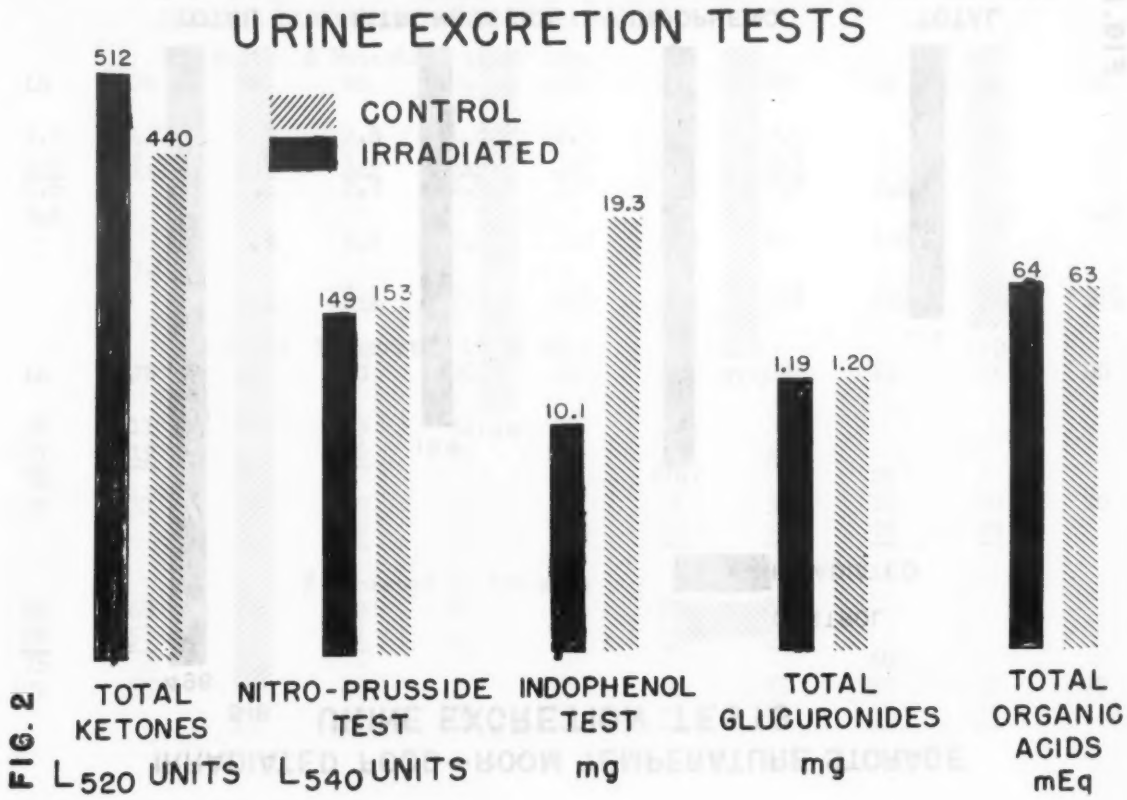

FIG. 2

APPENDIX 5

QUARTERMASTER FIELD EVALUATION AGENCY, U.S. ARMY
QUARTERMASTER RESEARCH AND ENGINEERING COMMAND
FORT LEE, VIRGINIA

TECHNICAL REPORT
T-81
57029-F

Troop Acceptability Tests of Radiation Preserved Pork and Bacon

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AUTHORIZATION
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PROJECT
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QUARTERMASTER FIELD EVALUATION AGENCY, U.S. ARMY
QUARTERMASTER RESEARCH AND ENGINEERING COMMAND
FORT LEE, VIRGINIA

TECHNICAL REPORT
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Troop Acceptability Tests of Radiation Preserved Pork and Bacon

September 1958

Abstract

Radiation preserved pork and bacon were evaluated by volunteer soldier consumers in an acceptability test conducted at Fort Lee, Virginia, during April and June 1958. Relative differences between comparable irradiated items and standard items were established under normal mess hall feeding conditions using the Quartermaster Food and Container Institute 9-point hedonic scale as the criterion measure. The irradiated pork served during the test had been stored in cans at room temperature for 10 months and the bacon for 12 months. Fresh, standard foods used in the test were obtained through normal supply channels at Fort Lee, Virginia. Differences between average hedonic scale values, each based on 60 individual ratings obtained for irradiated and non-irradiated barbecued roast pork, roast pork with gravy, and oven fried sliced bacon, showed the radiation preserved products to be equally acceptable to respective standard items.

1. Introduction.

Principal food preservation methods now in use place great emphasis on the destruction or control of food bacteria and other micro-organisms by the application of heat, as in canning, or the application of cold, as in freezing. Through its ability to destroy or inactivate micro-organisms present in foods, with little or no heat generated in the process, radiation shows great merit for future use as a food preserver.

In addition to its possible impact on the nation's food industry, the radiation food preservation concept should have potential application in Armed Forces feeding systems. The successful development of this process could not only result in a better means of retaining the desirable characteristics of fresh foods, but also provide at least a partial solution to many logistical problems (2).

Developments under the Army's radiation preservation of food program, under the over-all direction of the Quartermaster Corps, have now progressed to the point where large scale troop feeding tests are now required. It is anticipated that over the next 2 years approximately 20 food items representing typical meats, vegetables, and fruits will have been approved for this purpose. The first of these tests, in which irradiated and non-irradiated pork and bacon were served to soldier volunteers, was conducted at Fort Lee, Virginia, during April and June 1958.

2. Objective.

The objective was to determine the relative consumer preference for irradiated pork and standard fresh pork (Phase I), and irradiated bacon and standard fresh bacon (Phase II), when served as part of a normal meal under garrison feeding conditions (1).

3. Procedure.

a. Test personnel for both the pork and bacon phases of the test were obtained on a volunteer basis from units stationed at Fort Lee, Virginia. Approximately 2 weeks prior to initiation of the pork phase, a series of lectures on the subject of radiation preservation was presented by test personnel to approximately 2,000 men in various units on post. These lectures were designed to acquaint as many individuals as possible with the general historical background and progress of the radiation preservation of food program. Following each lecture personnel were canvassed to determine whether they would participate in the test on a volunteer basis.

In view of the requirement that each volunteer was to be given a physical examination immediately prior to and again approximately 3 months after participation, only those volunteers who would be present for duty at Fort Lee as of 31 August 1958 were selected for possible participation in the test.

b. Prior to each phase of the test specific toxicity and sterility tests on each of 20 No. 10 cans of the experimental item, i.e., pork or bacon, were made to determine the presence or absence of clostridium botulinum toxin and other bacterial micro-organisms. These tests were conducted in accordance with accepted animal assay procedures, utilizing appropriate laboratory facilities at Fort Lee. Laboratory tests were conducted by a civilian contractor, working under the supervision of a representative of the Office of The Surgeon General. A summary of microbiological tests conducted during both phases is shown in Appendix A.

c. Physical examinations of potential test subjects were conducted at the Fort Lee Hospital during the period 10 through 23 April 1958. Of the 302 volunteers examined, 249 were found to be physically qualified and available to participate in the test. Final examinations of only those men from this group who actually consumed one of the irradiated food items during the test were conducted during the period 12 through 15 August 1958. In both instances examinations were accomplished by a representative of the Office of The Surgeon General.

d. For the pork evaluation, 240 physically qualified Army volunteers participated in two test sessions conducted during the noon meal in a typical Fort Lee mess hall on 28 and 29 April 1958. At each session 120 men were served a complete meal. The meal included either irradiated pork loin which had been stored in cans at room temperature for approximately 10 months prior to the test, or fresh pork loin which had been obtained through normal supply channels. All remaining foods served at each session were essentially as delineated in appropriate master menus. All subjects were told that one of the foods served in each session was irradiated but were not told which one it was. Shown below are the test item recipe combinations served during each meal, and the number of individuals receiving the experimental and standard items.

Session No. 1

Test Foods Served	No. Subjects
Barbecued Roast Pork, Irradiated	60
Barbecued Roast Pork, Non-Irradiated	60

Session No. 2

Test Foods Served	No. Subjects
Roast Pork, Irradiated, w/Gravy	60
Roast Pork, Non-Irradiated, w/Gravy	60

Each subject was served approximately 4 ounces of pork, with standard portions of other items on the menu. Each individual rated four of the foods served. Ratings were recorded on a questionnaire containing 9-point hedonic scales for each of the four food items to be rated.

e. In conducting the bacon phase, 120 volunteers from among the original group of 240 participated in a single session conducted during the breakfast meal on 25 June 1958. Subjects were served a complete meal which included either irradiated bacon which had been stored in cans at room temperature for approximately 1 year prior to the test, or fresh sliced bacon which had been obtained through normal supply channels. All remaining foods were as shown in the appropriate master menu. Each subject was served three slices of bacon with other menu items, with one-half the participants receiving irradiated bacon and one-half receiving non-irradiated bacon. The rating procedure during this phase was identical to that of the pork phase.

f. During both phases estimates of plate waste were obtained. These were recorded on the basis of the fractional part of each individual serving of irradiated and comparable non-irradiated foods remaining on trays upon completion of any one meal.

g. Preparation of the experimental items was in accordance with recipes developed by the Quartermaster Food and Container Institute. The control products, and other foods served, were prepared in accordance with appropriate recipes outlined in TM 10-412.

4. Results and Discussion.

a. A summation of results obtained during the post wide orientation and screening of Fort Lee units to obtain potential volunteer subjects is shown in Appendix B. While a sufficient number of qualified individuals volunteered to meet the requirements of the test, as designed, it is apparent that the over-all effective volunteer rate was very low. This poor net result is primarily attributable to the requirement for physical examinations of participants before and after the test. There was no evidence

throughout the orientation procedure that fear of radiation per se had any appreciable effect on the volunteer rate.

b. Results of toxicity and sterility tests made on each of 20 No. 10 cans of irradiated pork and bacon prior to the troop evaluations of these items proved to be negative in all instances. Based on the data obtained all cans of irradiated food were found acceptable for troop feeding by (1) the contractor responsible for the conduct of specific laboratory tests, (2) the Quartermaster Food and Container Institute's Project Officer, (3) the assigned representative of the Office of The Surgeon General, and (4) the Veterinary Officer, Fort Lee, Virginia.

c. Of the 139 men who consumed irradiated pork and/or bacon during the test, 109 were present at Fort Lee to take the post-test physical examination. This examination revealed no effects which could be attributed to the consumption of the irradiated foods.

d. Tables I and II show average hedonic scale ratings for all food items rated by individuals during both sessions of the pork phase. Table III shows comparable data obtained during the single session comprising the bacon phase. Averages were computed on the basis of the following hedonic scale values: Like Extremely - 9, Like Very Much - 8, Like Moderately - 7, Like Slightly - 6, Neither Like Nor Dislike - 5, Dislike Slightly - 4, Dislike Moderately - 3, Dislike Very Much - 2, Dislike Extremely - 1.

TABLE I

AVERAGE HEDONIC SCALE RATINGS
(Pork Phase - Session 1)

Menu Items Rated	Avg. Rating	Number Subjects	Menu Items Rated	Avg. Rating	Number Subjects
Barbecued Pork, Irradiated	7.80	60	Barbecued Pork, Non-Irradiated	7.82	60
Mashed Potatoes	7.58	60	Mashed Potatoes	7.53	60
Green Beans	7.60	45	Green Beans	7.45	40
Strawberry Shortcake	8.18	60	Strawberry Shortcake	8.32	60

TABLE II

AVERAGE HEDONIC SCALE RATINGS
(Pork Phase - Session 2)

Menu Items Rated	Avg. Rating	Number Subjects	Menu Items Rated	Avg. Rating	Number Subjects
Roast Pork, Irradiated w/Gravy	7.82	60	Roast Pork, Non-Irradiated w/Gravy	7.98	60
Mashed Potatoes	7.72	60	Mashed Potatoes	7.45	60
Glazed Carrots	7.41	56	Glazed Carrots	7.13	54
Peach Shortcake	7.65	60	Peach Shortcake	7.64	59

TABLE III

AVERAGE HEDONIC SCALE RATINGS
(Bacon Phase)

Menu Items Rated	Avg. Rating	Number Subjects	Menu Items Rated	Avg. Rating	Number Subjects
Oven-Fried Bacon, Irradiated	7.32	60	Oven-Fried Bacon, Non-Irradiated	7.37	60
Eggs	7.64	59	Eggs	7.88	60
Cereal	8.08	24	Cereal	7.77	31
Toast	7.37	60	Toast	7.55	60

e. In view of the minute and non-significant differences between average ratings, it is apparent that both irradiated and standard pork and bacon were equally acceptable to the test subjects.

f. With regard to the levels of the ratings, there is evidence that all averages are inflated to some extent. Table IV shows partial results of a survey conducted in post mess halls prior to initiation of the irradiated food tests at Fort Lee. Average ratings shown are for those foods rated during the survey which were also included in the test of irradiated pork or bacon.

TABLE IV

AVERAGE HEDONIC SCALE RATINGS OBTAINED DURING PRETEST SURVEY ON FOODS ALSO INCLUDED IN TEST OF IRRADIATED FOODS

Food	Average Rating	No. Subjects Rating
Bacon	6.14	430
Mashed Potatoes	6.72	969
Green Beans	5.96	462
Carrots	5.39	355

g. Since the pretest survey results were obtained under more normal conditions of preparation and serving in many Fort Lee mess halls, and also in the absence of a testing situation, they can be considered as reasonably reliable indices of the acceptability of these foods as measured by hedonic scale ratings. The apparent large differences between the survey averages and those shown in Tables I, II, and III were probably due primarily to an unusually favorable attitude toward the test on the part of the participants. Prior to and during the test, national and local publicity was such that the receptiveness of the individuals who volunteered and the general attitude of the volunteers as a group could have been extremely favorable to the point of being atypical. A further indication of this lies in the fact that troops volunteered for participation in spite of a known requirement for physical examinations. To the extent that the subject sample was a homogeneous group in these, and possibly other respects, it lacked the degree of representativeness in make-up usually considered desirable and necessary for troop evaluations of this type.

h. Table V shows plate waste data obtained during the pork and bacon phases of the test. Included for each food is the over-all percentage of total servings not consumed during the test, as well as the average percentage of plate waste per serving for those individuals who did not consume all of their serving.

i. A "t" test of the significance of the differences between plate waste estimates for each irradiated and comparable non-irradiated item showed the difference to be significant at the 5 percent level of confidence for the pork but not significant for the bacon.

TABLE V

PERCENTAGES OF PLATE WASTE FOR IRRADIATED AND COMPARABLE NON-IRRADIATED FOODS

Food	Irradiated					Non-irradiated				
	Total No. of Servings	No. Subjects Consuming All of Serving	Less Than Full Serving Consumed		Over-all Percentage of Total Servings Not Consumed	Total No. of Servings	No. Subjects Consuming All of Serving	Less Than Full Serving Consumed		Over-all Percentage of Total Servings Not Consumed
			No. Subjects	Avg. Percentage of Serving Not Consumed				No. Subjects	Avg. Percentage of Serving Not Consumed	
Barbecued Roast Pork	60	54	6	46	5	60	32	28	34	16
Roast Pork Plain	60	57	3	33	2	60	39	21	24	9
Bacon	58[a]	49	9	32	5	56[a]	46	10	55	10

[a]Plate waste estimates not obtained for all 60 subjects.

j. The plate waste differences for pork cannot logically be attributed to chance occurrence; on the other hand, neither can they be considered to be due to the effects of irradiation. Most of the plate waste obtained for both irradiated and non-irradiated pork represented fat which would probably not be consumed under most circumstances. In addition, most of the surface fat on the irradiated pork used had been trimmed off prior to its being canned, precooked and irradiated. In an effort to make the test items as similar in appearance as possible, a certain amount of trimming was also done on the standard pork procured at Fort Lee; however, it was not possible to obtain complete uniformity in this respect. This was due first of all to the shrinkage which occurred during the precooking of the irradiated item, which made it difficult to judge the actual amount of fat on that product. In addition, the quantity of intermuscular fat was greater on the standard pork than on the experimental. A similar difference in the proportion of fat to lean meat was also noted for the irradiated and non-irradiated bacon used during the test; however, these items were basically more comparable than the pork products.

k. In view of the questionable reliability of the plate waste data shown, neither the actual percentages nor differences between percentages for comparable irradiated and non-irradiated foods should be considered indicative of the absolute or relative acceptability of these items.

5. Conclusions. Based on data obtained during a troop evaluation of irradiated and non-irradiated pork and bacon conducted at Fort Lee, Virginia, during the spring of 1958, it is concluded that:

a. Radiation preserved pork stored in cans at room temperature for approximately 10 months and prepared as barbecued roast is equally acceptable to similarly prepared fresh pork obtained through normal supply channels.

b. Radiation preserved pork stored in cans at room temperature for approximately 10 months and prepared as roast pork with gravy is equally acceptable to similarly prepared fresh pork obtained through normal supply channels.

c. Radiation preserved sliced bacon stored in cans at room temperature for approximately 12 months and prepared by oven-frying is equally acceptable to similarly prepared fresh sliced bacon obtained through normal supply channels.

6. References.

1. Letter, Headquarters Quartermaster Research and Engineering Command, QMCAL-MAG 7-84-01-002 57029, 14 February 1958, subject: "FEA 57029, Troop Acceptability of TTP Foods," and letter, QMCAL-FRPD, QM Food and Container Institute, 23 May 1958, subject: "Troop Evaluation Test of Irradiated Foods," and Indorsements thereto as follows: 1st Ind, QMRES-DFT, Headquarters Quartermaster Research & Development Command, 27 May 1958; 2nd Ind, QMRF FEA 57029, Headquarters QM R&E Field Evaluation Agency, 5 June 1958; and 3rd Ind, QMRES-DFT FEA 57029, Headquarters QM R&E Command, 17 June 1958.

2. "Radiation Preservation," Unpublished manuscript, QM Food and Container Institute, 20 May 1957.

Appendixes

Appendix A - Summary of Microbiological Tests Performed on Twenty Each No. 10 Cans of Irradiated Pork and Bacon.

Appendix B - Results of Troop Orientation Program at Fort Lee, Virginia, to Obtain Volunteer Test Subjects.

SUMMARY OF MICROBIOLOGICAL TESTS PERFORMED ON TWENTY EACH NO. 10 CANS OF IRRADIATED PORK AND BACON

Test No. 1, Mouse Exotoxin Assay - 0.5 ml. of a 1:10 aqueous suspension of the sample was administered to each of 5 male albino mice. Observations were made at 4, 24, 48 and 72 hours after injection.

Test No. 2, Total Plate Count - Standard plate count procedure for aerobic bacteria using M.P.H. agar medium; incubated 48 hours at 37°C.

Test No. 3, Test for Salmonella - Selenite broth medium was inoculated with an aqueous suspension of the sample and incubated for 24 hours at 37°C. Subcultures were then made to SS agar plates and these were incubated for 24 hours at 37°C.

Test No. 4, Test for Anaerobes - 10 ml. of a 1:10 aqueous suspension of the sample was inoculated into thioglycolate medium and incubated for 96 hours at 37°C. Absence of bacterial growth was checked by examination of stained smears from each tube.

RESULTS OF TROOP ORIENTATION PROGRAM AT FORT LEE, VA. TO OBTAIN VOLUNTEER TEST SUBJECTS

Organization	No. Troops Oriented	Potentially[a] Eligible Volunteers Obtained		No. Potential Eligibles Who Dropped Out Before Physical Examination	No. Given Physical Exam.	No. Failing Physical Exam.	No. Dropping Out for Other Than Physical Reasons	No. Subjects Physically Acceptable & Available for Test	Percentage of Total Troops Oriented Who Were Available for Test
		No.	Percentage						
543rd QM Grp.	1,350	190	14.07	5	185	27	5	153	11.33
9111th Det. 2 (FEA)	225	65	28.89	0	65	6	0	59	26.22
QM School	400	61	15.25	9	52	12	3	37	9.25
Totals	1,975	316	16.00	14	302	45	8	249	12.61

[a]Includes only those individuals who would still be at Fort Lee as of 31 August 1958.

APPENDIX 6

QUARTERMASTER FIELD EVALUATION AGENCY, U.S. ARMY
QUARTERMASTER RESEARCH AND ENGINEERING COMMAND
FORT LEE, VIRGINIA

TECHNICAL REPORT
T-104
58040-F

Troop Acceptability Tests of Selected Items of Radiated Foods

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AUTHORIZATION
FEA 58040

PROJECT
7-84-01-002

Howard W. Hembree, Ph.D.
Scientific Director

Arthur H. Nelson
Colonel, QMC
Commanding Officer

March 1959

QUARTERMASTER FIELD EVALUATION AGENCY, U.S. ARMY
QUARTERMASTER RESEARCH AND ENGINEERING COMMAND
FORT LEE, VIRGINIA

TECHNICAL REPORT
T-104
58040-F

Troop Acceptability Tests of Selected Items of Radiated Foods

March 1959

Abstract

A troop acceptability test was conducted to evaluate six radiated and six non-radiated foods. Volunteer soldier consumers were used in the test held at Fort Lee, Virginia, during November and December 1958. Relative differences between comparable radiated and standard items were established under normal mess hall feeding conditions.

The radiated items had been stored in cans at room temperature for approximately three months prior to the test. Control foods used were obtained through normal supply channels at Fort Lee.

Differences between average hedonic scale values, each based on approximately 100 individual ratings, showed a preference for the standard item over its radiated counterpart for Fried Chicken parts, Diced Buttered Carrots, and French Fried Shrimp. For similar comparisons involving Chicken Stew, Fruit Compote, and Pineapple Jam, there was no preference for either the standard or the radiated item. The only item of the radiated and standard foods tested not acceptable to the test subjects was the radiated carrots.

1. Introduction.

An integral part of the Quartermaster Corps program of research and development in the field of radiation food preservation is the troop feeding program initiated at Fort Lee, Virginia, during April 1958. At that time the first in a series of soldier acceptance evaluations, expected to encompass eighteen to twenty radiated foods during a two-year period, was conducted by the Quartermaster Research and Engineering Field Evaluation Agency in conjunction with the Quartermaster Food and Container Institute and the Office of The Surgeon General of the Army. In this initial project, soldier volunteers consumed and rated both radiated pork and bacon and the comparable standard items under normal garrison feeding conditions. Results of that study were published in QM R&E FEA Technical Report 57029, Number T-81, dated September 1958.

This report is concerned with the second large scale troop feeding test of radiated foods conducted during November and December 1958 under conditions similar to those in the first experiment. In this project, six additional radiated items were tested bringing the total number of such foods evaluated in the long range troop feeding program to eight.

2. Objective (1).

The objective of this project was to determine the relative consumer preference for each of the following radiated foods, and comparable control items, when served as part of a normal meal under garrison feeding conditions: (1) chicken (fried), (2) shrimp (deep fat fried), (3) carrots (diced), (4) chicken (stew), (5) fruit compote, and (6) pineapple jam.

3. Procedure.

a. Selection of Test Subjects.

Test subjects were obtained on a volunteer basis from among QM School units at Fort Lee. Prior to initiation of the project, a series of lectures on the subject of radiation preservation of foods was presented to potential test participants. Following each lecture personnel were canvassed to determine whether or not they would participate in the test on a voluntary basis. Volunteers were given physical examinations prior to and again approximately six weeks after participation. In both instances examinations were accomplished by a representative of the Office of The Surgeon General.

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b. Laboratory Analysis of Radiated Foods.

Specific toxicity and sterility tests were made on each can of radiated food to be used in the test to determine the presence or absence of clostridium botulinum toxin and other bacterial micro-organisms. These tests were conducted in accordance with accepted animal assay procedures utilizing appropriate laboratory facilities at Fort Lee. Laboratory tests were accomplished by a civilian contractor working under the supervision of a representative of the QM F&CI. A summary of micro-biological tests conducted is shown in Appendix A.

c. Design of Test.

The following experimental design was used in the conduct of the troop evaluation of the six radiated and six standard-of-comparison foods:

DESIGN OF TEST

First Replication

Session	Date	Test Subject Groups and Foods	
		Group I	Group II
1	3 Nov.	Fruit Compote, Radiated (Spiced Fruit Pie)	Chicken Stew, Radiated (Chicken Pot Pie)
		Chicken Stew, Standard (Chicken Pot Pie)	Fruit Compote, Standard (Spiced Fruit Pie)
2	6 Nov.	Chicken Parts, Radiated (Fried, Maryland Style)	Diced Carrots, Radiated (Parsley, Buttered)
		Diced Carrots, Standard (Parsley, Buttered)	Chicken Parts, Standard (Fried, Maryland Style)
3	10 Nov.	Shrimp, Radiated (Deep Fat Fried)	Pineapple Jam, Radiated
		Pineapple Jam, Standard	Shrimp, Standard (Deep Fat Fried)

DESIGN OF TEST (Cont'd)

Second Replication

Session	Date	Test Subject Groups and Foods	
		Group I	Group II
4	1 Dec.	Shrimp, Radiated (Deep Fat Fried)	Pineapple Jam, Radiated
		Pineapple Jam, Standard	Shrimp, Standard (Deep Fat Fried)
5	4 Dec.	Chicken Parts, Radiated (Fried, Maryland Style)	Diced Carrots, Radiated (Parsley, Buttered)
		Diced Carrots, Standard (Parsley, Buttered)	Chicken Parts, Standard (Fried, Maryland Style)
6	8 Dec.	Fruit Compote, Radiated (Spiced Fruit Pie)	Chicken Stew, Radiated (Chicken Pot Pie)
		Chicken Stew, Standard (Chicken Pot Pie)	Fruit Compote, Standard (Spiced Fruit Pie)

Test subject groups I and II, shown in the design, ranged from 101 to 107 individuals and were comprised only of physically qualified volunteers obtained during the pre-test orientations. Within each replication the group of 100-plus subjects available was arbitrarily divided in half to provide the two groups shown in the test design. Each group was served both a radiated and standard food at each session. Thus subjects in both Group I and Group II served as a control for the opposite group. Different subjects were used in each replication.

d. Troop Evaluation.

All test sessions were conducted in a typical mess hall at Fort Lee during regularly scheduled supper meals. At each session, all subjects were served standard portions of a complete meal which included a radiated food previously stored in No. 10 cans at room temperature for approximately three months prior to the test, and a control food obtained through normal supply channels at Fort Lee. All remaining foods served to subjects during each session were as delineated in the appropriate master menu. Subjects were told that one of the foods served to them was radiated but were not told which one it was. Each individual rated four of the foods served during

any one session. Ratings were recorded on a questionnaire showing a 9-point hedonic scale for each of the foods to be rated. Upon completion of the rating procedure estimates of plate waste were obtained. These were recorded on the basis of the fractional part of each individual serving of radiated, standard, and other non-radiated foods remaining on trays upon completion of any one meal.

4. Results and Discussion.

a. Physical Examinations of Subjects. Of the 224 men who consumed radiated foods during the test, 174 were present at Fort Lee to complete all post-test physical examination requirements. These examinations revealed no immediate specific effects which could be attributed to the consumption of radiated foods served during the test.

b. Laboratory Analysis of Radiated Foods. Results of toxicity and sterility tests made on each can of radiated food prior to the troop evaluation proved to be negative in all instances. Based upon the data obtained, all cans of radiated foods were found to be acceptable for troop test feeding by (1) the civilian contractor responsible for conduct of specific laboratory tests, (2) the Quartermaster Food and Container Institute Project Officer, (3) the assigned representative of the Office of The Surgeon General, and (4) the Veterinary Officer, Fort Lee, Virginia.

c. Troop Evaluation. Appendix B shows, by replication, the average hedonic scale ratings and plate waste estimates obtained for radiated, comparable standard, and other non-radiated foods served and rated during each session. Average ratings for radiated and standard foods only, combined over both replications, are listed in Table II with pertinent statements regarding the statistical significance of the difference between specific pairs of mean ratings. These data were analyzed using a variance analysis with independent F tests performed for each pair of mean ratings.

TABLE II

COMPARATIVE AVERAGE HEDONIC SCALE RATINGS FOR RADIATED AND STANDARD FOODS COMBINED OVER BOTH REPLICATIONS

Food Item	Radiated		Standard		Statistical Significance[a]
	Number Subjects Rating	Average Hedonic Rating	Number Subjects Rating	Average Hedonic Rating	
Chicken Stew (Chicken Pot Pie)	107	7.37	104	7.58	N.S.
Fruit Compote (Spiced Fruit Pie)	104	6.90	107	6.74	N.S.
Chicken Parts (Fried Chicken, Maryland Style)	101	7.38	103	7.95	SIG.
Diced Carrots (Parsley Buttered Carrots)	103	3.66	101	7.02	SIG.
Shrimp (Deep Fat Fried)	107	6.95	101	7.69	SIG.
Pineapple Jam	103	7.33	107	7.49	N.S.

[a]N.S. - Difference between mean ratings is not significant at the 5 percent probability level.
SIG. - Difference between mean ratings is significant at the 5 percent probability level.

While the statistical findings indicate a definite preference for the standard food over its radiated counterpart in three of the six comparisons shown in Table II, perhaps a more realistic evaluation of the relative merits of these items is to be obtained through evaluation of the magnitude of the numerical difference between comparative averages in relation to the effects of this difference on the rating levels per se.

When the numerical differences are considered in this light, as measures of the practical significance of the statistical findings, only in the case of carrots is the magnitude of the difference between means sufficient to adversely affect the level of the rating for the radiated product and to justify an outright assumption that the experimental food was distinctly inferior to the standard.

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The size of the numerical differences between means for radiated and non-radiated chicken parts and shrimp also suggests that subjects were aware, to some extent, of qualitative differences favoring the standard over the experimental items; however, it will be noted that the mean difference in both instances is such that the generally high levels of the ratings for these foods are not greatly affected. This would indicate that the sensory characteristics of the radiated items were, to say the least, satisfactory, and thus the preference shown for the standard food in each of these comparisons may not be of great practical importance.

In that the difference between comparable average ratings for any of the remaining three foods shown in Table II was neither statistically significant nor of any meaningful size, it may be assumed that no real differences exist, and that for each of these comparisons the radiated and standard foods were preferred equally.

Average percentages of total plate waste combined over both replications for radiated and comparable standard foods are shown in Table III. Percentages were computed on the basis of estimates of the fractional part of each serving of those items remaining on food trays upon completion of each session. These data were analyzed using a variance analysis and related F tests to determine the statistical significance of the difference between average percentages for comparable radiated and non-radiated items.

TABLE III

PERCENTAGES OF PLATE WASTE FOR RADIATED AND COMPARABLE STANDARD FOODS COMBINED OVER BOTH REPLICATIONS

Food Items	Over-all Percentage of Total Servings Not Consumed		Statistical Significance
	Radiated	Standard	
Chicken Stew	9.0	7.8	N.S.
Fruit Compote	23.8	31.9	N.S.
Chicken Parts	4.5	6.6	N.S.
Diced Carrots	57.5	18.3	SIG.
Shrimp	15.2	12.4	N.S.
Pineapple Jam	25.7	19.9	N.S.

Based on the difference between comparable average plate waste percentages obtained, it is apparent that, again, only for carrots is there a wide disparity between the radiated and standard items tested. The absence of statistically significant differences between plate waste percentages for any of the remaining foods shown in Table III tends to further minimize the importance of previously noted significant differences between average hedonic scale ratings for the same food pairings.

5. Conclusions. Based upon data obtained during a troop evaluation of radiated and non-radiated foods conducted at Fort Lee, Virginia, during November and December 1958, it is concluded that:

a. Chicken parts obtained fresh through normal supply channels are preferred to radiation-preserved chicken parts which have been stored in cans at room temperature for approximately three months, when both items are prepared and served as Fried Chicken, Maryland Style.

b. Carrots obtained fresh through supply channels are preferred to radiation-preserved carrots which have been stored in cans at room temperature for approximately three months, when both items are prepared and served as Diced Buttered Carrots.

c. Shrimp obtained fresh through normal supply channels are preferred to radiation-preserved shrimp which have been stored in cans at room temperature for approximately three months, when both items are prepared and served as French Fried Shrimp.

d. Radiation-preserved Chicken Stew stored in cans at room temperature for approximately three months and Chicken Stew prepared from fresh ingredients are preferred equally when prepared and served as Chicken Pot Pie.

e. Radiation-preserved Fruit Compote stored in cans at room temperature for approximately three months and canned Fruit Compote obtained through normal supply channels are preferred equally when served as Spiced Fruit Pie.

f. Radiation-preserved Pineapple Jam stored in cans at room temperature for approximately three months and canned Pineapple Jam obtained through normal supply channels are preferred equally.

g. With the exception of radiated carrots all of the radiated and comparable standard foods evaluated may be considered acceptable.

6. References.

1. Letter, Field Test Coordination Office, Headquarters Quartermaster Research and Engineering Command, QMCAL-MAG, 23 September 1958, subject: "FEA 58040, Troop Acceptability of Selected Items of Radiated Foods."

Appendixes

Appendix A - Summary of Micro-biological Tests Performed on Radiated Foods Tested.

Appendix B - Average Hedonic Scale Ratings and Plate Waste Estimates for all Foods by Session Within Replications.

SUMMARY OF MICRO-BIOLOGICAL TESTS PERFORMED ON RADIATED FOODS TESTED

Test No. 1, Mouse Exotoxin Assay - 0.5 ml. of a 1:10 aqueous suspension of the sample was administered to each of 5 male albino mice. Observations were made at 4, 24, 48, and 72 hours after injection.

Test No. 2, Total Plate Count - Standard plate count procedure for aerobic bacteria using M. P. H. agar medium; incubated 48 hours at 37°C.

Test No. 3, Test for Salmonella - Selenite broth medium was inoculated with an aqueous suspension of the sample and incubated for 24 hours at 37°C. Subcultures were then made to SS agar plates and these were incubated for 24 hours at 37°C.

Test No. 4, Test for Anaerobes - 10 ml. of a 1:10 aqueous suspension of the sample was inoculated into thioglycolate medium and incubated for 96 hours at 37°C. Absence of bacterial growth was checked by examination of stained smears from each tube.

AVERAGE HEDONIC SCALE RATINGS AND PLATE WASTE ESTIMATES FOR ALL FOODS
BY SESSION WITHIN REPLICATIONS

First Replication

Test Date	Foods	Subject Group I					Subject Group II				
		Std. or Rad.	No. Rating	Avg. Rating	Std. Error of Mean	Avg. Percent Plate Waste	Std. or Rad.	No. Rating	Avg. Rating	Std. Error of Mean	Avg. Percent Plate Waste
3 Nov.	Chicken Pot Pie	Std.	63	7.57	0.17	0.8	Rad.	65	7.65	0.15	5.6
	Buttered Noodles	-	63	6.95	0.22	10.2	-	64	7.14	0.20	15.9
	Spiced Fruit Pie	Rad.	63	7.30	0.19	20.2	Std.	65	7.18	0.23	30.2
	Buttered Peas	-	63	6.87	0.22	14.9	-	65	6.98	0.24	9.9
6 Nov.	Fried Chicken (Maryland Style)	Rad.	64	6.95	0.21	5.5	Std.	63	7.98	0.15	5.6
	Green Beans Parsley	-	64	7.05	0.19	10.6	-	63	7.11	0.19	7.1
	Buttered Carrots	Std.	64	7.00	0.20	17.2	Rad.	63	3.71	0.29	57.1
	Butterscotch Pudding	-	64	7.73	0.14	8.2	-	63	7.33	0.18	11.5
10 Nov.	French Fried Shrimp	Rad.	64	6.42	0.27	20.3	Std.	59	7.53	0.28	12.5
	Scalloped Potatoes	-	64	6.30	0.25	24.2	-	60	5.60	0.35	28.8
	Pineapple Jam	Std.	64	7.36	0.18	18.8	Rad.	60	7.40	0.20	20.8
	Apple Brown Betty	-	64	7.05	0.21	14.4	-	60	7.00	0.27	20.0

AVERAGE HEDONIC SCALE RATINGS AND PLATE WASTE ESTIMATES FOR ALL FOODS
BY SESSION WITHIN REPLICATIONS

Second Replication

Test Date	Foods	Subject Group I					Subject Group II				
		Std. or Rad.	No. Rating	Avg. Rating	Std. Error of Mean	Avg. Percent Plate Waste	Std. or Rad.	No. Rating	Avg. Rating	Std. Error of Mean	Avg. Percent Plate Waste
8 Dec.	Chicken Pot Pie	Std.	41	7.59	0.24	18.3	Rad.	42	6.95	0.29	14.3
	Buttered Noodles	-	41	7.37	0.17	32.3	-	42	6.95	0.25	14.3
	Spiced Fruit Pie	Rad.	41	6.29	0.39	29.3	Std.	42	6.05	0.34	34.5
	Buttered Peas	-	41	7.24	0.21	22.0	-	41	6.44	0.34	23.8
4 Dec.	Fried Chicken (Maryland Style)	Rad.	37	8.11	0.18	2.7	Std.	40	7.90	0.22	8.1
	Green Beans Parsley	-	37	7.54	0.19	5.4	-	40	7.12	0.28	20.6
	Buttered Carrots	Std.	37	7.05	0.23	20.3	Rad.	40	3.58	0.38	58.1
	Butterscotch Pudding	-	37	7.65	0.24	10.1	-	40	7.10	0.27	11.2
1 Dec.	French Fried Shrimp	Rad.	43	7.74	0.23	7.6	Std.	42	7.93	0.30	12.2
	Scalloped Potatoes	-	43	7.09	0.28	14.5	-	43	6.74	0.25	17.4
	Pineapple Jam	Std.	43	7.67	0.24	21.5	Rad.	43	7.23	0.21	32.6
	Apple Brown Betty	-	43	6.81	0.34	26.7	-	43	6.56	0.28	40.7

APPENDIX 7

SUMMARY OF OEEC-ENEA STUDY GROUP FIRST AND SECOND MEETINGS, MARCH-MAY 1960 ON FOOD IRRADIATION

SUMMARY OF FIRST MEETING OEEC/ENEA STUDY GROUP ON FOOD IRRADIATION, MARCH 10-11, 1960

The meeting was attended by representatives from 14 countries and three international organizations, i.e., Euratom, FAO and IAEA. Mr. Germain Mocquot (France) was elected chairman.

The first day was devoted primarily to discussions of country activities and plans. The group demonstrated great interest in the report given by Mr. Robert Rodden on the status of the U. S. program and the proposal now under consideration for the initiation of a civilian program.

The discussion of country programs and available sources led to an exchange of views concerning the need for more and larger sources. The question of mobile units brought forth a wide range of views. The U. K. rep (Ley) questioned the desirability of completely mobile units, although he agreed that there was a requirement to transfer sources from one fixed installation to another. Lafontaine (Belgium) was concerned about the safety aspects of mobile units. (Throughout the meeting Lafontaine repeatedly referred to the possible hazards arising from any work in food irradiation).

The March 11 session was devoted to summing up and agreeing to the content, conclusions and recommendations of the required report. Ley (U.K.) proposed that a special group be established to assess where and how irradiation can be fitted into food processing in Europe. This group would examine both the technical and economic feasibility of application of irradiation to specific food items. This proposal was accepted.

Saeland (ENEA) summarized the conclusions of the meeting as follows:

1. If adopted, the civilian program in the U. S. will influence greatly the proposals of the Study Group.
2. National efforts and cooperative studies should concentrate on basic problems at present, although studies of application to certain foods should be initiated or supported even now.
3. Studies on wholesomeness of irradiated foods are of primary importance.
4. The economic factor being ultimately decisive, any applied studies should be directed towards foods or food products which, currently, appear the most susceptible to improved storage life with low dosage treatments.
5. Special meetings on specific topics in this field should be promoted.
6. A plan for the joint use of large sources should be developed.
7. The potential of existing food research centers should be expanded when possible, in order to conserve scarce manpower and for financial reasons.
8. A cooperative research program should consider the advantages of devising the program on the basis of regional interests in the production of certain foods or food products.
9. There should be a detailed study on the need for additional sources and facilities, including economic studies.

All the representatives accepted Saeland's summary.

The next meeting was scheduled for May 6, 1960, to review a draft of the report.

SUMMARY OF SECOND MEETING OEEC/ENEA STUDY GROUP ON FOOD IRRADIATION, MAY 6, 1960

The Study Group was established by the European Nuclear Energy Agency of OEEC for the purpose of developing a plan for a coordinated European program on low dose radiation processing of food to extend shelf life. The initial meeting of the Study Group was held on March 10 and 11, 1960, at which time the United States was represented by Major Robert M. Rodden. A second meeting was held on May 6, 1960, at which the United States was represented by Mr. Joseph E. Machurek, USAEC. The purpose of this meeting was to review a draft report developed as a consequence of the first meeting.

During the meeting the U. S. representative presented a brief summary of the current status of the AEC program on low dose radiation processing of food and the Department of the Army program for high dose radiation sterilization. This was received with a great deal of interest. In addition, he provided the ENEA Secretariat with copies of the AEC testimony at the March 31, 1960, JCAE Hearings, as well as the March 11, 1960, brochure on the Department of the Army program.

The Study Group reviewed the previously prepared draft report in very great detail. A series of recommendations were adopted as follows:

a. A preliminary evaluation should be made of the economic and engineering feasibility of the specific applications envisaged for food irradiation in the Member Countries, giving special consideration to applications with public health advantages.

b. A survey should be made of existing irradiation facilities in the Member Countries and a proposal worked out whereby large radiation facilities

suitable for development work on selected applications would be made available.

c. In collaboration with appropriate international organizations a proposal should be worked out for the setting up of a panel which should review and discuss the problems relating to the health and safety of irradiated food, collect and distribute relevant information and assist member governments regarding these questions.

d. Plans should be made for a close working contact between any joint OEEC programs on food irradiation and similar programs of other countries including particularly the United States.

The Study Group report as revised at this meeting is to be presented to the Steering Committee on Nuclear Energy, ENEA, by June 1, 1960. At that time it will also be recommended that in order to work out detailed proposals along the lines of the foregoing recommendations, the work of the Study Group should be continued. Anticipating approval of this, the Study Group agreed to meet again, probably in October.

At the request of Dr. E. Saeland, Deputy Director, ENEA, the U. S. representative met with him, Dr. N. Desrosier, consultant to OEEC and Mr. Frank Ley of the United Kingdom, Wantage Radiation Laboratory, on May 7, 1960. One purpose of this meeting was to discuss the methods the USAEC was employing in implementing its low dose radiation processed foods program. Details of the Commission's initial technical and economic feasibility studies under contracts with Stanford Research Institute and Massachusetts Institute of Technology were of great interest. Dr. Saeland felt similar studies would be necessary in carrying out the European program.

A second purpose of this meeting involved the question of setting up formal procedures for exchanging information between the United States and OEEC on their respective programs. It was indicated that the AEC's testimony before the JCAE on March 31, 1960, specifically identified the Commission's desire to exchange information in this field with other countries. Dr. Saeland said he would investigate in what way OEEC could reciprocate and then initiate a formal proposal through appropriate channels for routine information exchange.

It is apparent that the OEEC Member Countries are vitally interested in the details of the United States program. Furthermore, the fact that the AEC program has been established and the Army program continued carries great weight and enhances United States prestige. Continued United States interest and cooperation in the OEEC program not only would be helpful to the Member Countries and desirable from an international relations viewpoint, but also would be of positive value to the United States in terms of having the benefit of technology developed in the OEEC program.

APPENDIX 8

BIBLIOGRAPHY

Catalog of Technical Reports

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Order from LC mi $2.40 ph $3.30 AECU-3343

Columbia Univ.
FOOD IRRADIATION AND ASSOCIATED STUDIES, QUARTERLY PROGRESS REPORT (includes milk sterilization) by Gaden. 1951, 16p.
Order from LC mi $2.40 ph $3.30 NYO-3317

Columbia Univ.
FOOD IRRADIATION AND ASSOCIATED STUDIES. QUARTERLY PROGRESS REPORT (includes milk, butter and oleic acid-radiation effects). 1952, 35p.
Order from LC mi $3.00 ph $6.30 NYO-3318

Mass. Inst. of Tech.
A CRITICAL EVALUATION OF THE LITERATURE PERTAINING TO THE APPLICATION OF IONIZING RADIATIONS TO THE FOOD AND PHARMACEUTICAL FIELDS, by Proctor and Goldblith. 1952, 242p.
Order from LC mi $9.90 ph $34.80 NYO-3337

Mass. Inst. of Tech.
QUARTERLY PROGRESS REPORT FOR JAN - MARCH 1952 (includes food sterilization and effects of Co^{60} on Escherichia coli) by Proctor and Goldblith. 1952, 29p.
Order from LC mi $2.70 ph $4.80 NYO-3338

A CONCEPTUAL DESIGN OF A FOOD IRRADIATION REACTOR, 1956, 370p.
Order from OTS $6.50 AECU-3361

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON THE PRESERVATION OF FOODS BY IONIZING RADIATIONS JULY 27 - JULY 30, 1959. 294p.
Order from OTS $4.00 TID-7585

Technical Information Service, AEC
GLASS DOSIMETERS FOR RADIATION MEASUREMENT (includes measurement of doses in food and drug sterilization) by Schulman. 1956, 18p.
Order from OTS 20 cents TID-8006

TRANSLATIONS

THE EMPLOYMENT OF ULTRAVIOLET RADIATION FOR THE STERILIZATION OF CERTAIN OBJECTS IN FOOD PRODUCTION by Z.A. Ignatovich and E.I. Olenieva. 1958, 7p.
Trans. of Voprosy Pitaniya (USSR) 1955, v. 14, no. 1, p. 39-44.
Order from OTS 50 cents 59-11203

THE AFTEREFFECT OF IONIZING RADIATION ON THE VITAMIN C AND CAROTENE CONTENT OF CERTAIN PREPARATIONS AND FOODSTUFFS by G.M. Yegiazarov. 1959, 4p.
Trans. of Voprosy Pitaniya (USSR) 1958, v. 17, no. 5, 9-11.
Order from OTS 50 cents 59-11432

ON THE FORMATION OF TOXIC AGENTS DURING RADIATION STERILIZATION by M.N. Shalnova. 1959, 6p.
Trans. of Zhurnal Obshchey Biologii (USSR) 1958, v. 19, no. 3, p. 234-236.
Order from OTS 50 cents 59-13360

IMPROVEMENT OF CHOCOLATE THROUGH ULTRASONICS. IMPORTANT INNOVATIONS (1959) 2p.
Trans. of Zucker- und Susswarenwirtschaft (West Germany) 1957, v. 10, p. 787-788.
Order from ATS $4.00 59-18879

RESEARCH ON THE EFFECT OF FREEZING MEAT BEFORE GAMMA RADIATION by L. Brunelet and Pierre Vidal. 1959, 6p.
Trans. from mono. Recherches sur l'Influence de la Congelation des Viandes Avant Irradiation par les Rayons Gamma, Moscow, 1958.
Order from OTS 50 cents 59-21067

SOME ASPECTS OF THE PROBLEM OF PACKAGING FOOD PRODUCTS WHICH HAVE BEEN STERILIZED BY IONIZING RADIATION by L. Brunelet and Pierr Vidal. 1959, 9p.
Trans. from Revue Generale du Froid (France) 1958, July.
Order from OTS 50 cents 59-21068

RELATED STUDIES

Olin Mathieson Chemical Corp., New Haven, Conn.
TESTING PROGRAM FOR IRRADIATED PACKAGING FILMS by Simari. Rept. no. 5 (Final) 1957, 30p.
Order from LC mi $2.70 ph $4.80 PB 139596

Rock Island Arsenal Lab., Ill.
GAMMA RADIATION OF PACKAGING MATERIALS by Garland. 1959, 19p.
Order from OTS 50 cents PB 161097

Fission Products Lab., Univ. of Mich.
NUCLEAR ACTIVATION WITH COBALT-60 GAMMA RAYS. (food radioactivity-induced in) by Meinke. 1954, 16p.
Order from OTS 15 cents AECU-2904

Food and Drug Admin., Wash., D.C. and Federal Civil Defense Admin., Battle Creek, Mich.
EFFECTS OF NUCLEAR EXPLOSIONS ON BULK FOOD STAPLES by Rowe. 1956, 38p.
Order from OTS 30 cents WT-1163

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EFFECTS OF NUCLEAR EXPLOSIONS ON CANNED FOODS by Greenleaf and others. 1956, 89p.
Order from OTS $2.25 WT-1212

THE EFFECT OF NUCLEAR EXPLOSIONS ON SEMI-PERISHABLE FOODS AND FOOD PACKAGING by Hardenburg and Ryall. 1956, 59p.
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EFFECTS OF NUCLEAR EXPLOSIONS ON FROZEN FOODS by Schmitt. 1956, 17p.
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THE EFFECT OF NUCLEAR EXPLOSIONS ON MEAT AND MEAT PRODUCTS by Philbeck and Doty, 1956, 41p.
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EXPOSURE OF FOODS AND FOODSTUFFS TO NUCLEAR EXPLOSIONS (covers over 100 different foods). A SUMMARY OF RESULTS, by Laug. 1956, 19p.
Order from OTS 50 cents WT-1222

EFFECT OF FALLOUT CONTAMINATION ON PROCESSED FOODS, CONTAINERS, AND PACKAGING by Luninger and others. 1958, 17p.
Order from OTS 75 cents WT-1496

THE EFFECT OF NUCLEAR EXPLOSIONS ON COMMERCIALLY PACKAGED BEVERAGES by McConnell and others. 1956, 18p.
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AIP
American Institute of Physics
335 East 45th Street
New York 17, New York

API
Academic Press, Inc.
111 Fifth Avenue
New York 3, New York

ATS
Associated Technical Services, Inc.
P.O. Box 271
East Orange, New Jersey

BINB
Circulation Manager
Translations of the Beltone Institute for Hearing Research
2900 West 36th Street
Chicago 32, Illinois

BISI
The Iron and Steel Institute
4, Grosvenor Gardens
London, S.W. 1, England

CB
Consultants Bureau, Inc.
227 West 17th Street
New York 11, New York

CCT
Consultants Custom Translations, Inc.
227 West 17th Street
New York 11, New York

CHP
Cleaver-Hume Press, Ltd.
31 Wright's Lane
London, W. 8, England

CIDNT
Centralny Instytut Dokumentacji Naukowo-Technicznej
Warszawa 12
Aleja Niepodleglosci 188
Poland

CSIRO
Commonwealth Scientific and Industrial Research Organisation Information Service
314 Albert Street
East Melbourne C. 2, Victoria, Australia

CTT
Columbia Technical Translations
5 Vermont Avenue
White Plains, New York

EIS
Engineering Information Services
Kirkham, Preston, Lancashire, England

HB
Henry Brutcher
P.O. Box 157
Altadena, California

HMSO
Her Majest's Stationery Office
P.O.B. 569
London, S.E. 1, England

HTCBN
Hungarian Trading Company for Books and Newspapers "Kultura"
Budapest 62, P.O. Box 149

IP
Interscience Publishers, Inc.
250 Fifth Avenue
New York 1, New York

LC
Photoduplication Service
Publication Board Project
Library of Congress
Washington 25, D.C.

LSA
Literature Service Associates
Route 1
Bound Brook, New Jersey

MACL
Maclaren and Sons, Ltd.
Maclaren House
131 Great Suffolk Street
London, S.E. 1, England

MUF
Morris D. Friedman, Inc.
P.O. Box 35
New Newton 65, Mass.

NASA
National Aeronautics and Space Administration
1520 H Street, N.W.
Washington 25, D.C.

NRCC
National Research Council, Library
Ottawa 2, Canada

OTS
Office of Technical Services
Department of Commerce
Washington 25, D.C.

PERA
The Information Manager,
Production Engineering Research Association
Melton Mowbray
Leicestershire, England

PLP
Plenum Press, Inc.
227 West 17th Street
New York 11, N.Y.

PP
Pergamon Press
122 East 55th Street
New York 22, New York

PS
Primary Sources
11 Bleecker Street
New York 12, N.Y.

RIS
Research Information Service
40 East 23rd Street
New York 10, New York

SLA
SLA Translation Center
The John Crerar Library
86 East Randolph Street
Chicago 1, Illinois

TF
Taylor and Francis Ltd.
Red Lion Court, Fleet Street
London, E.C. 4, England

TIC
Technical Information Company
Patents Department, Chancery House
Chancery Lane
London, W.C. 2, England

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Pittsburgh 13, Pennsylvania

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Price Gilbert Library
Atlanta, Georgia

Massachusetts Institute of Technology Libraries
Building 14
Cambridge 39, Mass.

The Pennsylvania State University
University Park, Pa.

University of California
Engineering Library
Los Angeles, California

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